SCIENTIFIC AMERICAN

No. SUPPLEMENT 482

Scientific American Supplement, Vol. XIX., No. 482.
Scientific American, established 1845.

NEW YORK, MARCH 28, 1885.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE NIAGARA CANTILEVER BRIDGE.

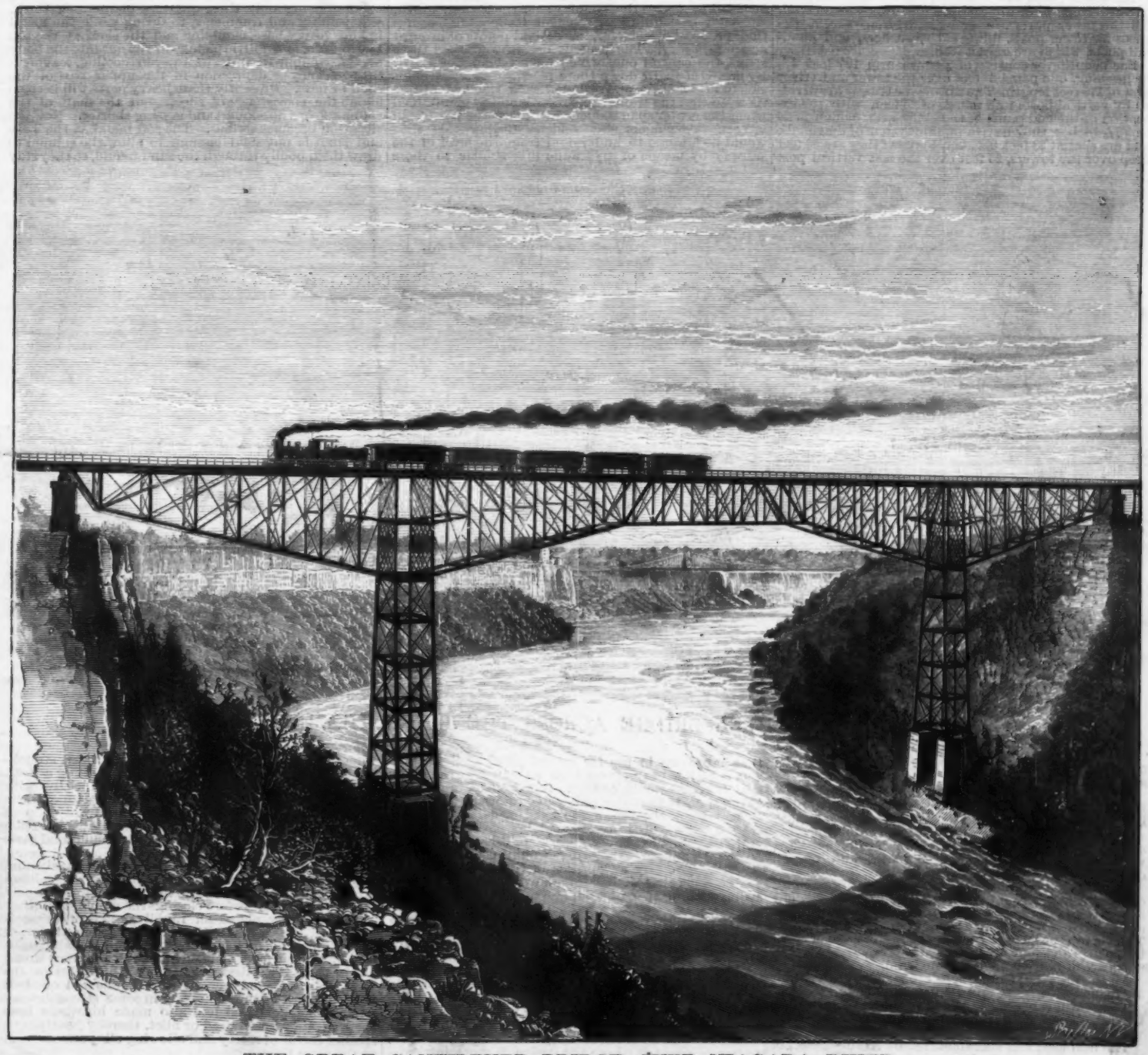
AT a meeting of the American Society of Civil Engineers in this city, a paper on the Cantilever Bridge at Niagara Falls, by C. C. Schneider, M. Am. Soc. C. E., was lately read by the author. The preliminary study and estimate for this double track railroad bridge was made at the request of the Central Bridge Company of Buffalo, by Mr. Schneider, in October, 1882, and he at that time concluded that the river span should be so designed as to allow it to be erected without false works, and that a hinged arch on the cantilever principle would be the proper form of construction, he having in the spring of 1882 designed the Fraser River Bridge for the Canadian Pacific Railway, where similar conditions existed precluding the use of false works. After securing a profile of the site, the design and estimates were perfected, and a tender for the construction of the entire work submitted by the Central Bridge Company to the Niagara River Bridge Company, and after approval by their Consulting Engineer, Mr. Charles H. Fisher, M. Am. Soc. C. E., the contract was awarded on April 11, 1884, to the Central Bridge Company, on condition that the structure be completed on December 1 of the same year. The contracts for portions of the work were sublet: excavations and masonry to Dawson, Simmes & Mitchell; false works to C. H. Turner; beton foundations to John C. Goodridge, Jr.; steel and iron compression members for towers to Kellogg & Maurice.

Mr. Schneider was appointed, by the Niagara River Bridge Co., Chief Engineer on April 26. The work, both at the bridge site and the shops, was vigorously pushed, and the bridge was completed and opened for traffic on December 20, 1883, about eight months from the commencement of the work.

The bridge is over the Niagara River, about two miles below the Falls and 300 feet above the Railroad Suspension Bridge. The bridge spans a chasm of 850 feet in width and 210 feet in depth to the surface of the water. The river is 425 feet wide at the bridge site; the water has a velocity of 16¼ miles per hour at the center of the river. The depth is supposed to be from 50 to 80 feet. The banks on both sides slope at about 45 degrees from the water's edge to about 50 feet below the top of the cliff, above which they are horizontal. The sloping banks consist of a mass of large bowlders and broken stone from the hard limestone layer which forms the upper stratum, mixed with earth and *debris*. This hard limestone, which has been undermined by the water acting upon it and cutting away the argillaceous rocks, has fallen in hard masses and formed a natural rip-rap, preventing further erosion. The pits for the towers at the water's edge were in this loose, hard stone. No solid rock was found. It was determined to prepare the bed for the masonry upon the very large bowlders at the bottom of the pits by filling to a depth of about 8 feet with beton Coignet, well rammed into all interstices on bottom and sides. The foundation area for each pair of piers is about 1,000 square feet, and the weight about 5,930,000 pounds, or 5,930 pounds per square foot. The stability of this foundation was considered by two commissions of engineers, both of which commissions expressed themselves satisfied as to their stability. The members of these commissions were Messrs. George S. Morison, Charles Macdonald, John A. Wilson, A. W. Stedman, and Theodore Cooper.

The masonry of the piers is limestone laid in cement. They are 38 feet high above the beton. The stones were lowered from the trestle, afterward used for erection of the towers and shore arms of the cantilevers. The anchorage piers are on the top of the cliffs. They are built on a platform of plate-girders, connected by anchor-bars to the shore ends of the cantilevers, thus utilizing the weight of the whole mass of masonry of the piers. Each anchorage pier weighs about 2,000,000 pounds.

The towers are 182½ feet from top of masonry to centre of lower chord of cantilevers. Each tower consists of four main posts, with horizontal struts and



THE GREAT CANTILEVER BRIDGE OVER NIAGARA RIVER.

diagonal tie-rods. Each post is formed of steel plates and angles. The horizontal struts divide the towers into five sections of nearly equal height. The posts have a batter of 1 in 8 at right angles, and of 1 in 48 parallel to the axis of the bridge. The distance between centers of posts at their base is 60 feet 7¼ inches at right angles, and 30 feet 5⅛ inches parallel to the axis of the bridge. They rest on cast-iron shoes at the bottom. The tops consist of steel castings, which support the cantilever on 7½ inch steel pins.

The structure carries a double track. It consists of two cantilevers resting on the towers, the shore ends being anchored to the anchorage piers, and the river ends connected by an intermediate span. The distance between centers of anchorage piers is 910 feet 2½ inches; length of each cantilever, 395 feet 2 5/16 inches; length of intermediate span, 119 feet 9⅝ inches. The moving load assumed in proportioning the structure was a train on each track headed by two 66-ton locomotives, having 72,000 pounds on three pairs of drivers, spaced 6 feet between centers, followed by a train load of 2,000 pounds per lineal foot. The floor system is proportioned for 78-ton consolidation engines. The lateral system is proportioned to resist a wind-pressure of 30 pounds per square foot on a train surface of 10 feet height, and upon the exposed surface of truss and floor system; the pressure on the train surface being considered a moving load. Strain sheets accompany the paper.

The tower posts, lower chords, center and end posts of cantilevers, pins, top-castings for towers, are of steel. All the other parts are of wrought iron, except the shoes for tower posts, filling rings, washers, and hand-rail posts, which are of cast iron.

Each cantilever consists of a shore arm 195 feet 2 5/16 inches long, one panel 25 feet over the tower and a river arm of 175 feet length. The cantilever trusses are divided by vertical posts into panels of 25 feet, with the exception of the end panel of the shore arm, which is 20 feet 2 5/16 inches; they have a double system of diagonals, and are spaced 28 feet between centers; they are 56 feet deep over the towers, 26 feet over the last vertical post at the river end, and 21 feet over the last vertical post at the shore end.

The upper chords of the shore arm receive alternate tensile and compressive strains; loads which are applied between the anchorage and the tower produce compression, and those applied to the river arm or intermediate span produce tension. These chords are of eye-bars, with a compression member of plates and angles, double latticed, packed between the bars.

The upper chord in tower panel and the upper chord of river arm are composed entirely of eye-bars. The lower chords and inclined end posts of the cantilevers are steel compression members of plates and angles. The vertical posts over the tower supports are of steel, two plates and four angles. The intermediate vertical posts are of two channels double laced.

All the principal connections are made by steel pins 5¾ inches, 6¾ inches, and 7⅛ inches diameter.

The cantilevers are connected to the anchorage piers by rockers permitting horizontal movement.

The intermediate span has five panels of 24 feet.

The iron used was manufactured by Atkins Bros., of Pottstown, and Graff, Bennett & Co., of Pittsburg. The steel was made by the Spang Iron and Steel Company, of Pittsburg. The steel pins and castings were made by the Cambria Iron Company. All the materials were manufactured into finished members at the shops of the Central Bridge Works, at Buffalo, except the compression members for the towers, which were made at the shops of Kellogg & Maurice, at Athens, Pa.

The heads of the eye-bars were formed by die forging.

The towers were erected by means of derricks on the false works, the material being lowered from the cliffs to the floor of the false works and thence to the towers. The tower on the American side was begun August 29 and finished September 8; that on the British side was begun September 10 and finished September 18. The shore arms of the cantilevers were then erected on the false works, a track laid on them, and the travelers for the construction of the river arms put in position. These were substantial wooden frame-works on iron wheels. The travelers were fastened by clamps to the floor-beams of the completed portion. Each traveler had two derricks connected with a hoisting engine, by means of which the materials were lifted from cars and lowered to their place in the structure. A hanging platform was suspended from the traveler.

The American shore arm was begun September 25, completed October 15. The Canadian shore arm was begun October 8, completed October 22. The American river arm was begun October 28; the Canadian river arm was begun November 4. The last connection was made November 22. The first track was completed December 6, on which day a locomotive crossed the bridge. The whole structure was completed December 19.

The bridge was formally opened and tested in the presence of a large number of engineers on December 20, 1883. The tests were conducted by a committee, Messrs. George S. Morison, Theodore Cooper, Charles Macdonald, and Thomas Rideout. The inclemency of the weather at that date made another series of tests desirable, which were conducted by the same engineers, whose report accompanies the paper. The specifications for the bridge and the report of tests on eye-bars also accompany the paper.

PROPOSED NEW BRIDGE OVER THE THAMES.

Messrs. Kinipple & Morris have submitted to the trustees of the Bridge House Estate a design for a low-level bridge across the Thames near the Tower, which, although resembling in some of its leading features their proposal of last year, has several points of interest and originality. The present design comprises three spans, the central one, which opens, being of 250 ft. By means of shafts down these piers, communication is effected with a subway underneath the bed of the river, so that the traffic can be continuously maintained when the center span is opened to allow the passage of vessels. Passengers and vehicles during this time would be lowered to, and raised from, the level of the subway by means of hydraulic lifts similar to those

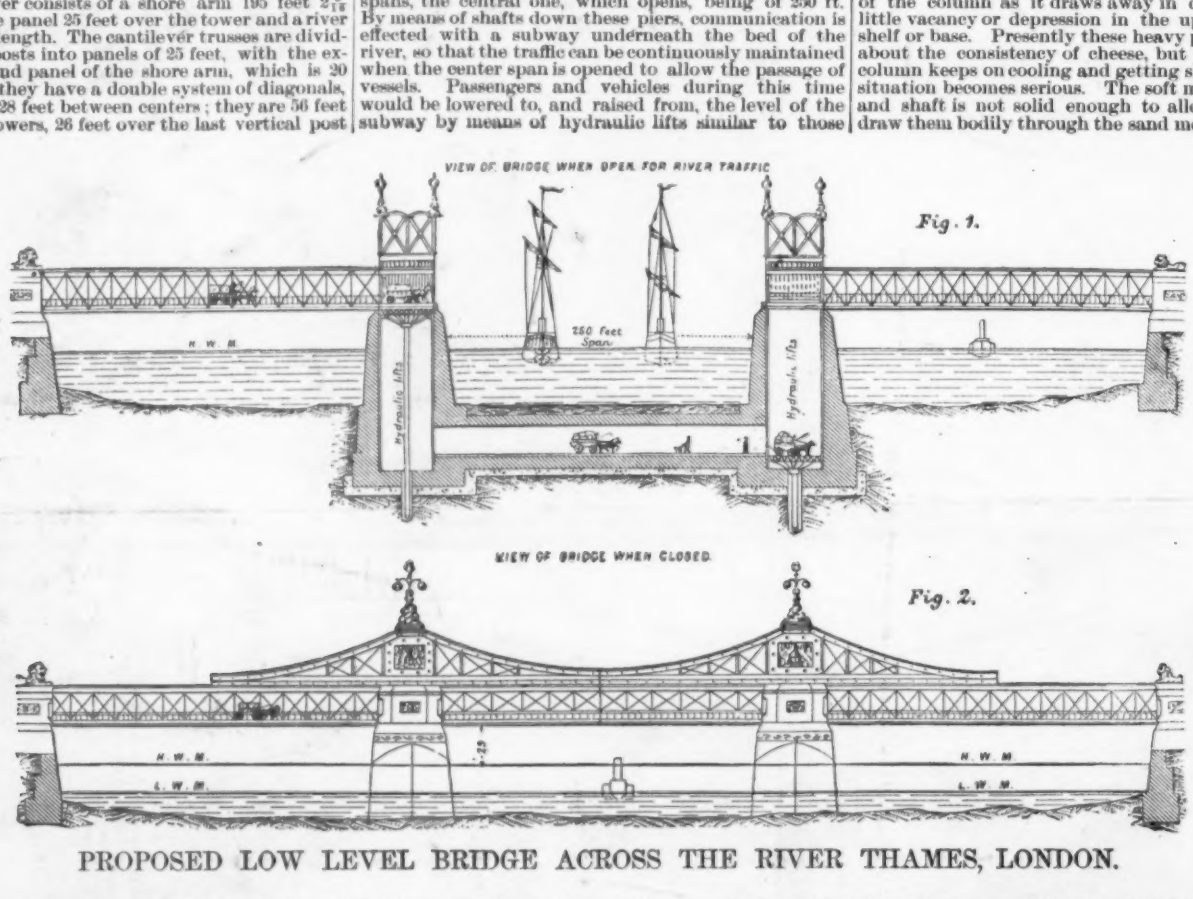


Fig. 1.

Fig. 2.

PROPOSED LOW LEVEL BRIDGE ACROSS THE RIVER THAMES, LONDON.

that have been in use for several years at Seacombe. The clear headway above high water when the swing span is closed would be 29 ft. A special feature of this swing span is that the tails or counterweights would swing clear of the top of the fixed girders. The illustration represented above explains clearly the general features of this design, which, it is estimated by Messrs. Kinipple & Morris, would cost, complete, 500,000*l*. The city authorities of Glasgow propose to erect a somewhat similar bridge over the Clyde with a swing opening span of 300 ft.—*Engineering.*

SOUND CASTINGS AND FACTORS OF SAFETY.*

So many disturbing elements intervene between the conception of a design in cast iron and the completion of the work in the building, that we all have to allow what we call a factor of safety (aptly characterized by the late Alexander L. Holly, C.E., as a factor of ignorance) to cover these contingencies, varying from three, or one-third the breaking strain in very simple cases where the quality of the castings can be depended upon, to five or even ten where the design is more intricate, or the liability to shrinkage strains, hidden defects in the castings, rough bearing surfaces, or uncertain variations of the load are possible. Much can be done by designers of cast-iron work to reduce this factor of safety, and consequently the weight and cost of castings, by giving serious consideration to the many processes and changes of condition through which their designs pass on the road to the building. Foundrymen exercise great ingenuity in producing any design in iron that may be presented to them; still it is possible to design things that are totally impracticable in cast iron, in which case the designer would probably be asked to modify his drawing; but when it is possible to carry out a design without change, it is the almost universal practice to do so without comment and without recollection of the fact that the resulting castings may have very serious shrinkage strains or other defects, which would reduce the strength far below what the designer expected. For instance a column, say sixteen feet long, eight inches in diameter, three-quarter inch metal, is sometimes designed with a heavy projecting base moulding near the bottom, say twelve or fourteen inches in diameter, giving three inches or more thickness to the metal at that point, also having an extension of the shaft to pass down through a shell plinth or pedestal, while at the top there is a shell cap and then a shelf, say twelve by twenty-four inches, for girders, made, possibly, two and one-half or three inches thick, to insure strength without the use of brackets or ribs.

This, like all other architectural work, will be moulded in "green sand," which is moulding sand slightly dampened with water and rammed solidly around the wood pattern, forming a mould strong enough to withstand the wash and pressure of molten iron running into the mould. When we consider that iron weighs four hundred and fifty pounds per cubic foot, while water weighs only sixty-two and one-half, an idea may be formed of the strength of mould necessary to stand the wash and pressure, which, in a mould three feet high from the bottom of the casting to the top of the gate, where the iron is poured in, is fourteen hundred and forty pounds per square foot, nearly three-quarters of a ton on each square foot of surface; consequently the sand must be firm.

Now, realize that the pattern for this sixteen-foot column is made sixteen feet two inches long, to allow for shrinkage; also remember that when this shrinkage occurs, something has got to give. The shaft of your column, being only three-quarters of an inch thick, will solidify and commence to shrink while the metal in your heavy base moulding and the shelf at the top is still fluid, and a little metal will run out into the body of the column as it draws away in cooling, leaving a little vacancy or depression in the upper part of the shelf or base. Presently these heavy parts will become about the consistency of cheese, but the shaft of the column keeps on cooling and getting shorter. Now the situation becomes serious. The soft metal in the base and shaft is not solid enough to allow the column to draw them bodily through the sand mould, so they stay where they are, and the column shrinks away, stretching out more of the soft metal after it, making a weak place or leaving a nice little crack to be filled up with putty before the column is painted, and in an extreme case pulling away so much that the head will drop off when the column is hoisted out of the mould. Then the foundryman looks wisely at the column and says, "Now I will fix you," and puts a fillet around below the shelf, or a bracket, which will cool quickly and help pull, chipping out the bracket when the column is cold. In case all these fail, he just lays in some cold pieces of pig iron before closing the mould, and they cool the heavy places off rapidly, and everything is lovely. This last makes the soundest job in the lot, as they all melt down together; still there is liable to be dirt on the surface, and shrinkage strains that would not be there if the designer had made his metal in the shelf only one and one-quarter or one and one-half times as thick as the shaft, put in some strengthening ribs or brackets, and had also made his whole base shell, except a small bead or fillet, thereby justifying a smaller factor of safety and allowing all parts to cool at the same time.

Mullion columns are often designed with a heavy square face cored out, which stands in front of the wood frames, while a thin web runs back between the sash-weight boxes. This is an exceedingly hard shape to cast without shrinkage strains. The cored part in front only radiates heat from one side (the core being quickly heated through), while the webbed back runs away off toward the remote parts of the mould, giving off heat on both sides, and the extreme back edge radiates in all directions but one, thereby cooling much faster than the front part, so that when the back has attained its length for normal temperature the front is still red-hot, and much longer. When the front cools, there results a strain which gives this column all it can do to hang together until it gets into the building, without doing its full share of work after getting there. Moral: A good, liberal factor of safety, or a nice large rib of metal, round or square, on the back of the web to keep it from cooling too fast. The privilege of modifying the thickness of parts of castings to avoid shrink-

* From the hand-book of the Union Foundry and Pullman Car Works of Chicago.

age strains is one that a designer can safely give a foundryman, for it is always cheaper to make castings right than wrong, to commence with. Still, any foundryman can call to mind numerous instances in which he has received serious rebuffs when he has volunteered advice which he considered good to designers who did not care to hear it, consequently they are often backward about volunteering their opinions. Unequal cooling and consequent crookedness of shell pilaster faces, frieze plates, and light ornamental work is usually corrected by the foundryman without asking the designer's permission, as it is utterly impossible to get light work straight without providing for equal and uniform cooling.

But in the manufacture of thicker pieces and parts intended to sustain loads of any kind, the foundryman never makes changes or asks permission to change, if he can possibly execute the work as per drawings received. Generally speaking, a more intimate association between designers and executors of cast iron would result in a great saving of metal and a reduction of the factors of safety. Imperfect and unsound castings, owing to carelessness in the manufacturing, are much more rare than is generally supposed. Cold shuts from pouring the metal too cold, honeycombs, dirt, and scabs from soft or unclean moulds are quite rare, and never dangerous in the work of reputable foundries. Many more bad castings are made through an honest endeavor to carry out a design which is not positively the best thing possible for the place than from carelessness in the execution of the work.

Among the most noticeable indications of shrinkage strains in finished castings is crookedness. One side will be shorter, thereby giving the whole piece a crook, or in the case of wide plates they sometimes appear with the center perfectly straight and both edges "loose," or apparently too long for the center. The same may be said of the thin back ribs sometimes put on mullion columns. This comes from the apparently long parts cooling first, so that when the heavier parts cool afterward the light parts are left too long for their places, while the loss of strength incident to these causes is usually provided for by the enormous factors of safety used. Still, if designers would examine their castings carefully, they would soon be able to design forms not liable to these defects, and reduce their factors of safety accordingly.

Any foundryman will be only too glad to show designers of cast-iron work through his shops, and will be able to point out many important conditions affecting the success and quality of castings, which our space will not permit us to mention. We feel confident that as architects and designers of cast iron take a closer interest in the numerous processes of the foundry they will appreciate the fitness of and use cast iron more frequently.—*C. W. Trowbridge.*

THE LAST TRIAL OF ARMOR PLATES AT SPEZIA.

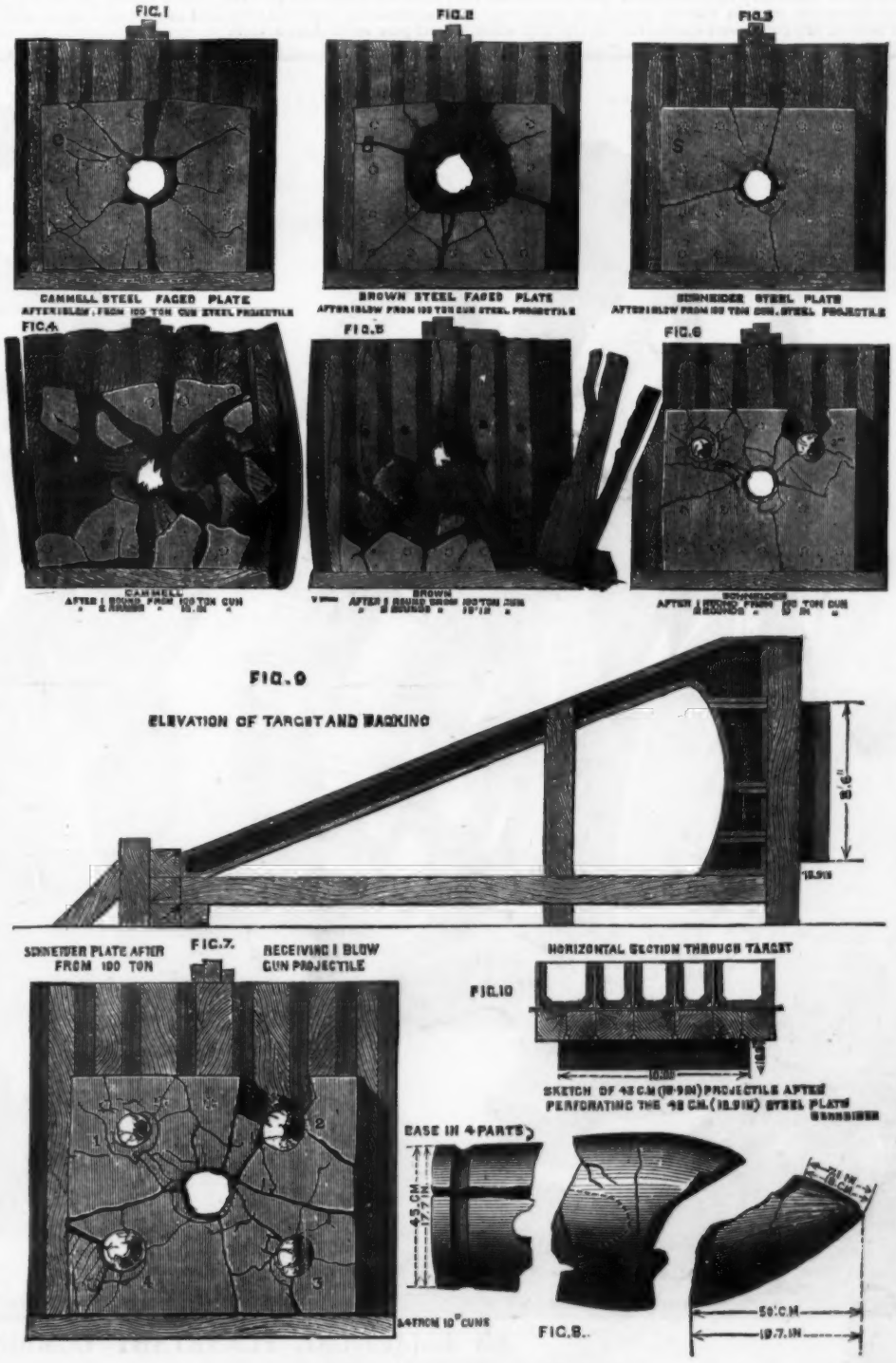
THE trial at Spezia last October was specially interesting. We are informed that on its result depended the order for the plates for the Lepanto. The programme was as follows: Cammell and Brown compound and Schneider steel plates 10 ft. by 8 ft. 6 in. by 18·9 in. (3,050 mm. by 2,600 mm. by 480 mm.) were mounted on frame and backing shown in Figs. 9 and 10. One round was to be fired at the center of each plate from the 100 ton breech-loading Armstrong gun, with a projectile weighing 1,841 lb. (835 kg.) with a striking velocity of 1,864 ft. (568 m.) per second, making a blow of 44,340 foot-tons, or 8,337 foot-tons per inch circumference, implying a calculated perforation of 30·27 in. of iron, and, taking the target's weight as 29 tons, an amount of energy of 1,529 foot-tons per ton of plate. As the greatest amount of energy per ton of plate in the previous Spezia trials was 1,046 foot-tons, while the calculated perforation through iron was 25·2 in., it may be seen that this test was very severe indeed; in fact, the plates were enormously outmatched on any standard of estimation. The effects are shown on the Cammell-Brown and Schneider plates respectively in Figs. 1, 2, and 3. The steel-faced plates obviously suffered much more than the steel one, but there appeared distinct reason to think that they had done more toward stopping the projectile than the Schneider plate, inasmuch as the shot went through the latter in a much more complete condition. We have received a drawing of the fragments taken out of the butt subsequently, which we give in Fig. 8. It was argued fairly enough that a shot with less velocity might have been stopped altogether by the steel-faced plate, while the steel plate would have allowed it to pass through, and further, that the backing was much softer than a ship's side, and that this was in favor of the steel plate, which, while having a less hard face, has, as a mass, "more bone in it." This argument we thought might be fairly held at this stage of the trial. The plates were next subjected to the fire of the 10 in. gun, with a striking velocity of about 2,000 ft., with the following results—on November 5, 6, and 7:

Brown's plate, penetration first round, 12·6 in. (320 mm.), a great part of plate detached; second round, the plate demolished to the extent shown in Fig. 5. About three-fourths of the plate being now stripped off, further firing was impossible.

Schneider's plate then received two blows, producing cracks and fracture to the extent shown in Fig. 6, which is given for the sake of comparison with the steel-faced plates. The shot is stated in the French accounts to have been more broken up against the steel than against the steel-faced English plates. Two more rounds were fired with the 10 in. gun, the plate at the conclusion of the programme being in the condition shown in Fig. 7.

Cammell's plate was then attacked, broken pieces of plate being thrown off to an amount estimated at nearly 5 tons—5,000 kilogs.—by the first round, and the plate being brought to the condition shown in Fig. 4 in the second round with the 10 in. gun—a condition which made further firing useless. The Schneider steel has, therefore, on this occasion won a remarkable victory. We could wish that the English plates had beaten it, but it is idle to ignore the fact that they were beaten. It may of course be argued that the steel-faced plates absorbed so much of the energy of the first heavy blow that they were afterward in a worse position than the Schneider, which let it through more easily. The natural reply is that the makers knew the tests that would be applied, and should have made the plates to stand well under these conditions; and few would sacrifice the power of holding together shown by the steel for the possibility that the steel-faced plate might have kept out fire, while the steel admitted it in some hypothetical case. The Italian Government have, we are informed, ordered plates for the Lepanto from Schneider, but this statement is, we believe, premature.

As far as we are able to form a conclusion from the above, it would be that on this scale our compound armor is behind Schneider's. It is possible that Cammell and Brown may snatch the victory on some future occasion, especially if better means are found of working very thick plates, but at present we are inclined to think that it is only true wisdom to recognize the liability of steel-faced iron on this scale to fail to exhibit the powers of steel armor as made by Schneider. All the compound armor victories have been with thinner plates. We should by no means say that the compound principle, if carried out with hard and soft steel, may not be the best, but when the results we give occur repeatedly with iron, and with intervals of time sufficiently wide to develop manufacturing operations fairly well, it is idle to shut our eyes to them. Without seeing the targets themselves, there is evidence enough in the drawings to tell something to those who have seen previous results. For example, the crack in the steel below the letter S precisely resembles the long vertical crack in the Schneider plate fired at in 1882 in its character. There may be seen a succession of short, disconnected cracks, looking in the sketch like the twists in a rope, which are very characteristic. We trust we may hear of success before long with steel faces on steel foundation plates, which have now been some time under trial. At all events, we can afford not to be discouraged about steel-faced iron armor. We have spoken here of the blow of 1,529 foot-tons per ton of plate being an enormous one, and quite out of proportion to the resisting power of the plate. We may remind our readers that at Shoeburyness a compound Cammell plate on granite bore a blow of 2,870 foot-tons, the plate stopping the shot without breaking—*vide Engineer*, September 28, 1883. The circumstances were, of course, special, but the strain must have been enormous. We have never seen steel tried under the same circumstances, and, as in other cases, the plate was comparatively small, being 12 in. thick. We may, however, say that a shield behaving in so remarkable a manner must have elements of great power. We may add that we believe before long Sir W. Armstrong may be making steel armor as well as Sir J. Whitworth.—*Engineer.*



ARMOR PLATES AT SPEZIA.

CREEPING OF RAILS.

H. W. REED, master of roadway of the Savannah, Florida, and Western Railway, sends to *Engineering News* the following regarding Johnson's paper on the creeping of rails on the St. Louis bridge (see *Review*, January 10, 1885):

The phenomena of the movement of rails in track are so variable that several hypotheses will undoubtedly be required to explain them all. I think that Professor Johnson has shown very clearly one of the causes for the creeping of rails, viz., a wave motion causing an extension of the lower fibers and a consequent creeping or rolling action. I will not undertake to consider these phenomena in detail, but will simply explain an expedient which has been resorted to on the Savannah, Florida, and Western Railway for preventing the creeping of rails, and which has been eminently successful. At some point we have a trestle about one-half mile in length; on this trestle there is laid a 50-pound steel rail connected with outside and inside angle plates slotted and spiked to the ties. At times, particularly during the warm weather, the creeping movement of the track was such that spikes and bolts were sheared off or torn out, and angle plates torn asunder. On these occasions, immediately after the passage of heavy freight trains, joints were found open 7, 12, and 18 inches respectively. To remedy this, angle plates were bolted on each side of every rail at the center and spiked in the slots, enough space being allowed at joints for expansion. Thus

each rail is held independent of the adjacent rails, and the movement produced in it, either by pressure of wheels or by change in temperature, affects only itself. For two years there has been no continuous movement of rails at this point. At other points on our line, where trouble was usually experienced in hot weather by the combined action of creeping and expansion, and where ties were driven several feet out of position, in the adoption of this and other simple devices we have found a complete remedy.

[Continued from Supplement No. 470, page 7500.]

PLANETARY WHEEL TRAINS.

By Prof. C. W. MacCord, Sc.D.

V.

ELLIPTICAL EPICYCLIC TRAINS.—VARYING VELOCITY RATIO.—PLANETARY TRAINS WITH INTERMITTENT MOTION.

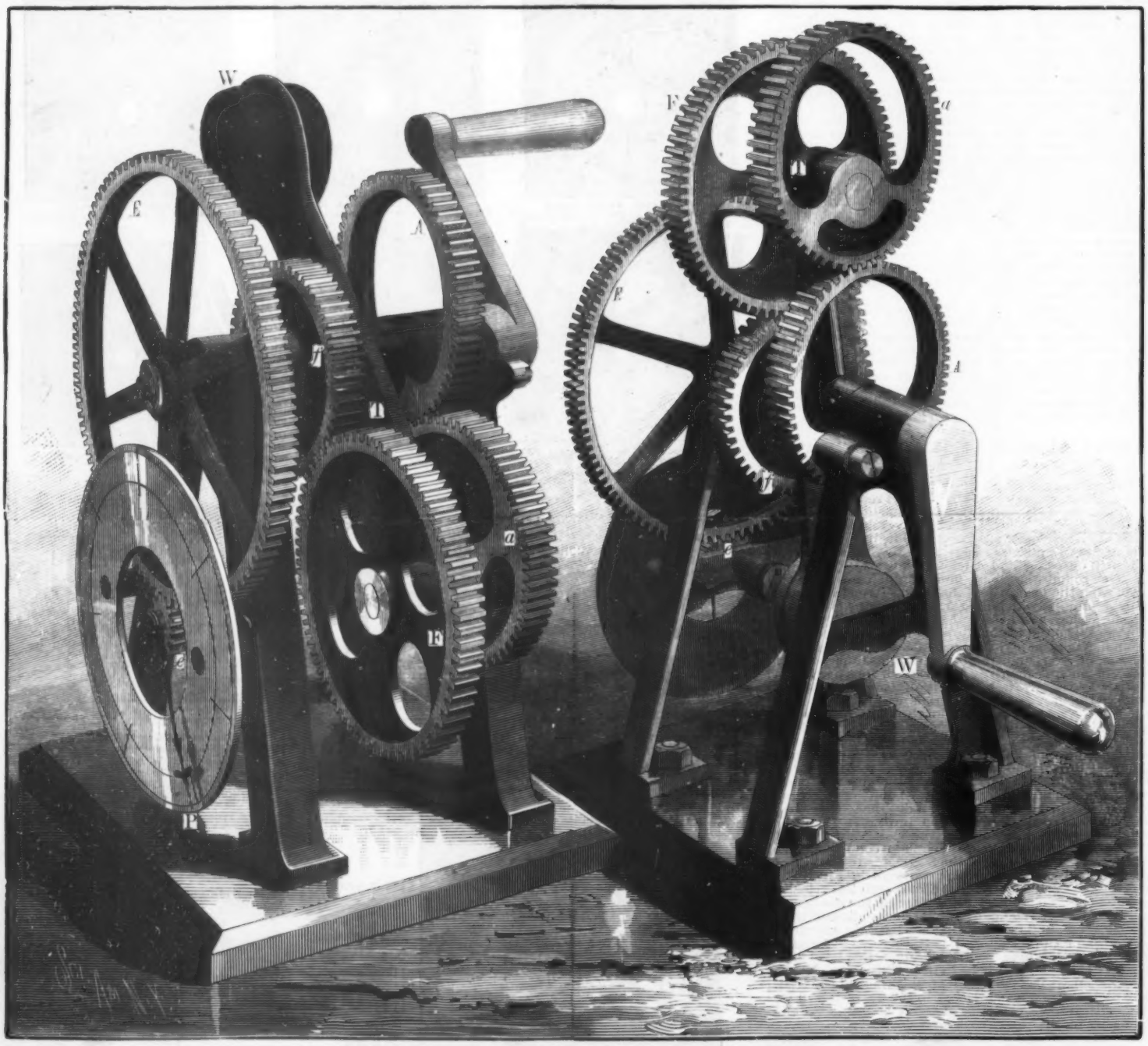
All the planetary combinations that have thus far been discussed, and in fact all that have ever come to our notice, are composed exclusively of circular wheels: and in consequence, if the velocity of the driver or drivers be uniform, the velocity of the driven shaft is also uniform.

But, as is well known, two equal and similar ellipses, centered upon corresponding foci, are capable of rotating in perfect rolling contact; the distance between these foci being equal to the major axis. This being so, it is apparent that if one of these ellipses be fixed, and the other one made to roll around it, the distance between those foci will be constant and equal to that major axis. Connecting the traveling with the fixed focus by a train-arm, then, we have an elliptical planet whose axial motion is not constant, but varying. We may then complete the train by adding a second planet and a free sun-wheel, thus obtaining a varying velocity ratio as the resultant action.

It may be urged that a varying velocity ratio is directly obtained by the use of a single pair of elliptical or other non-circular wheels, without the complication of the planetary device.

This variation, however, is usually between two limits of sensible magnitude, and without change in the directional relation. Thus, a pair of elleptical wheels always turn in opposite directions, and the velocity ratio varies between reciprocal limits determined by the eccentricity: if, for example, the focus divides the major axis into two parts, m and n, the greatest and least values of the velocity ratio will be $\frac{m}{n}$, $\frac{n}{m}$, both fractions being positive. But by means of the planetary combination above suggested, one of these limits may be reduced to zero or even made negative—and various curious results may be reached, which at least are abstractly rather interesting, and may be found, possibly, suited to some practical purposes.

The general arrangement (see perspective view), of course, does not differ from that of the differential train of four spur wheels, as is shown in Fig. 47; A is the fixed ellipse, a the planetary one, while the pair, f, F, are here made circular wheels: on the shaft of the latter is fixed another wheel, E, driving a pinion, e, which carries an index, P, thus making an illustrative model for exhibiting the peculiarities of the motions. The train-arm T is shown as provided with a counterweight, W, it being manifestly impossible to balance a train of this kind by using two pairs of planet-wheels as in Fig. 31, because the opposite elliptical ones would be in different phases of their action.



AN ELLIPTICAL PLANETARY COMBINATION.

In Fig. 48, the focus, C, cuts the major axis, L N, into segments, L C, C N, having the ratio of 1 to 3, and the wheels, f, F, are of equal diameters. At the instant when the extremities of the minor axes are in contact at P as shown, D P is equal to P C, and the angular velocities of the axial and the orbital motions of the pair, a, f, are equal, and since f = F, the latter wheel is stationary. The same state of things will again occur when the opposite extremities of the minor axes come together at Q; a in the mean time having rolled half way round A. The effect upon F will be perhaps most clearly seen by supposing O to rotate as shown by the arrow until it reaches P (the train-arm remaining at rest), and the arm with its wheels then to revolve until D reaches E. Now, in the ellipse here employed, C being one focus, G the other, and R the center, C L = N G = ¼ C N = ⅓ L R, and since P C = L R = P G is equilateral, whence P C G = C D K = 60°. Consequently, the radius O D, in moving forward as shown by the arrow to the position P D, turns about D through an angle of 240°; that rotation of f, then, would cause F to make two-thirds of a rotation backward. Then the train-arm, moving through 120° from its present position, C D, to the new position, C E, would carry F one-third of a revolution forward: so that the final result is, that F makes one-third of a revolution backward, during this portion of the motion of the arm. In completing its revolution, the train-arm would carry F through two-thirds of a turn forward, but the rotation of f would give it one-third of a turn backward; the difference is one-third forward. We have, then, that F moves alternately backward and forward, through an arc of 120°, the time required for the forward motion being double that required for the other.

Next, in regard to the limits between which the velocity ratio varies. The equation of the train is

$$\frac{V'}{v'} = 1 - \frac{A}{a}\frac{f}{F};$$

and the maximum velocity of F will evidently be reached when D reaches H, the points M and N being then in coincidence, giving $\frac{V'}{v'} = 1 - 3 = -2$. The minimum will be reached when the train-arm points downward, K then coinciding with L, and giving the value

$$\frac{V'}{v'} = 1 - \tfrac{1}{2} = + \tfrac{1}{2}.$$

In the above example, the motion of F consists in a mere oscillation through a certain fixed arc; and it may be said that the same result may be produced by other and simpler means, as, for example, by the crank and slotted arm. (Thus, in Fig. 49, the proportions are such that the lever, L, swings through an arc of 120°, the times of the forward and backward motions having also the same ratio as in Fig. 48, viz., that of 2 to 1.) This is true; but the arrangement under consideration is capable of producing results not so easily imitated. Thus, in Fig. 50, the angles of the triangle P C G are respectively 90°, 60°, and 30°, whence P G = P D = 2 P C; also, f = 2 F. At the present instant, then, F is at rest, and will be so again when D has moved forward to E; this orbital motion tending to move F also through a half revolution. But in the mean time, f turns upon its axis through ½ of a complete rotation, which tends to give F ½ of a revolution backward. During this half revolution of the train-arm, then, F actually turns backward 1½ times. During the other half revolution, f makes ½ of a rotation, so that F moves forward through ½ − ½ = ½ of a turn only. Suppose the train of Fig. 47 to be thus proportioned, and let the wheel, E, be six times as large as the pinion, e; then during one-half turn of the crank, the pointer, P, will

make *seven* turns forward, and during the other half, *one* turn backward: a rather singular result, when we consider that it is produced by a direct-acting train of wheels, with no oscillating, reversing, or shifting pieces.

In both these cases, since the motion of F *is* reversed, the variation of the velocity ratio is between two limits, one of which is positive and the other negative. But by varying the relative diameters of *f* and F, one limit may be made exactly equal to zero; in which case F is at rest for an instant, but its motion is always in the same direction. Thus, in Fig. 51, the ellipses are the same as in Fig. 48, but F is three times as large as *f*: and we have for the limits of the variation,

$$\text{Minimum,}\quad \frac{V'}{v'} = 1 - \frac{3}{1} \times \frac{1}{3} = 0.$$

$$\text{Maximum,}\quad \frac{V'}{v'} = 1 - \frac{1}{3} \times \frac{1}{3} = \frac{8}{9}.$$

It is clear from the figure that F is at rest when the train-arm has the position C D; in going forward to the position C E, the orbital motion of *f* would give F a half turn, in the same direction; but the axial motion would move it backward, $\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$ of a revolution; the same will occur during the other half turn of T; so that ultimately F makes $\frac{2}{3}$ of a revolution forward during each complete turn of the train-arm.

In Fig. 52, the ellipses are still the same, but F is only one-third as large as *f*; and we have for the limiting values of the velocity ratio,

$$\frac{V'}{v'} = 1 - \frac{3}{1} \times \frac{3}{1} = -8,$$

$$\frac{V'}{v'} = 1 - \frac{3}{3} \times \frac{3}{1} = 0;$$

so that F is at rest for one instant also in this case, but its motion is always in the opposite direction to that of the train-arm. When the latter is in the position C D, the follower is at its maximum speed; in going forward to the position C E, the orbital motion of *f* would, as in Fig. 51, carry F half way round in the same direction, but the axial motion would move it backward $\frac{1}{2} \times \frac{3}{1} = 1\frac{1}{2}$ turns; the final result, then, is that during each revolution of the train-arm, the follower makes two complete revolutions, in the opposite direction.

But again, the diameters of *f* and F may be so proportioned that the limits of variation shall be equal in magnitude, though of contrary signs. Thus, in Fig. 53, the ellipse being the same as in Fig. 52, let *f* be to F as 3 to 5. Then the limits are

$$\frac{V'}{v'} = 1 - \frac{3}{5} \times \frac{3}{1} = +\frac{4}{5};$$

$$\frac{V'}{v'} = 1 - \frac{3}{5} \times \frac{3}{1} = -\frac{4}{5}.$$

In order to determine the resultant angular motion of F under these conditions, it is necessary first to ascertain the positions in which F is at rest. This evidently will occur when the contact radii of *a* and A are directly proportional to *f* and F, as D P, P C. We have, then, merely to divide L N, the major axis, into segments having the ratio of 5 to 3, and with the greater as radius to describe an arc cutting the ellipse at P, which will be the point of contact.

In the present case, the sides of the triangle C P G thus determined are to each other as 5, 3, and 4 respectively, which makes P G C a right angle; the other angles are then easily calculated, and we find P C G = 36° 52′ 12″ very nearly, whence D C E = 73° 54′ 24″, a close approximation to $\frac{77}{375}$ of the circumference. Through this angle, then, C D must move forward to

Fig. 47.

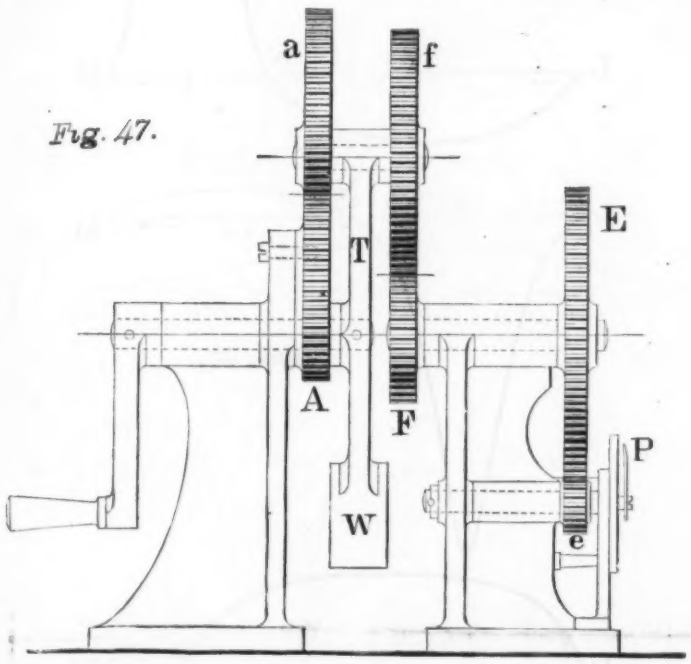


FIG. 48.

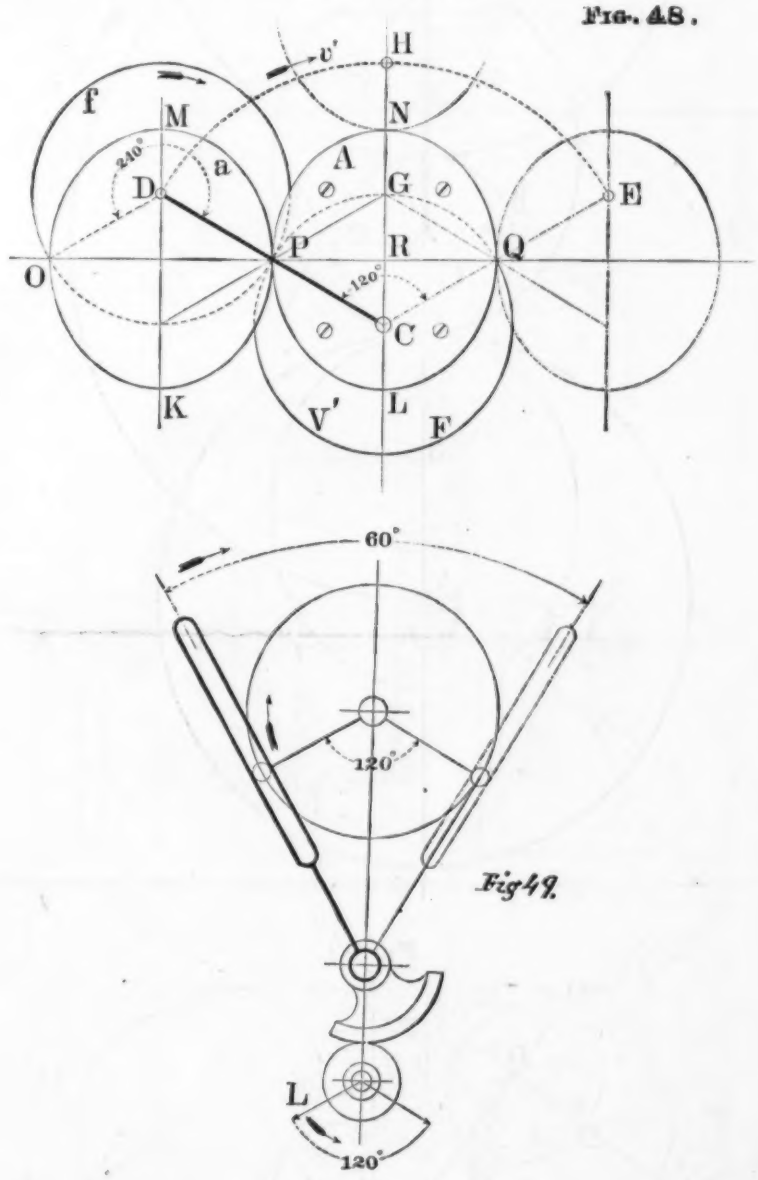


Fig 49.

FIG. 51.

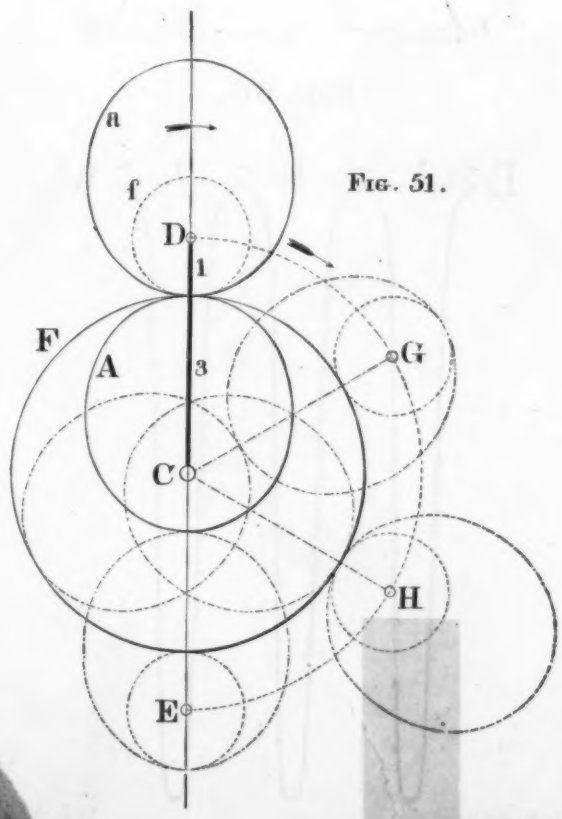
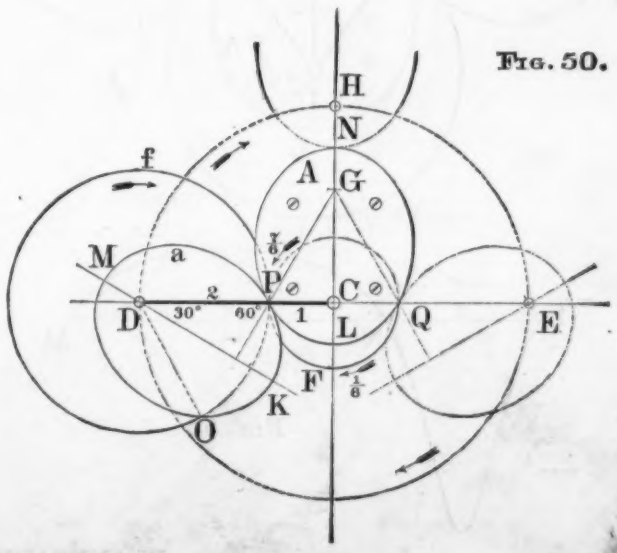


FIG. 50.



PLANETARY WHEEL TRAINS.

Fig. 52.

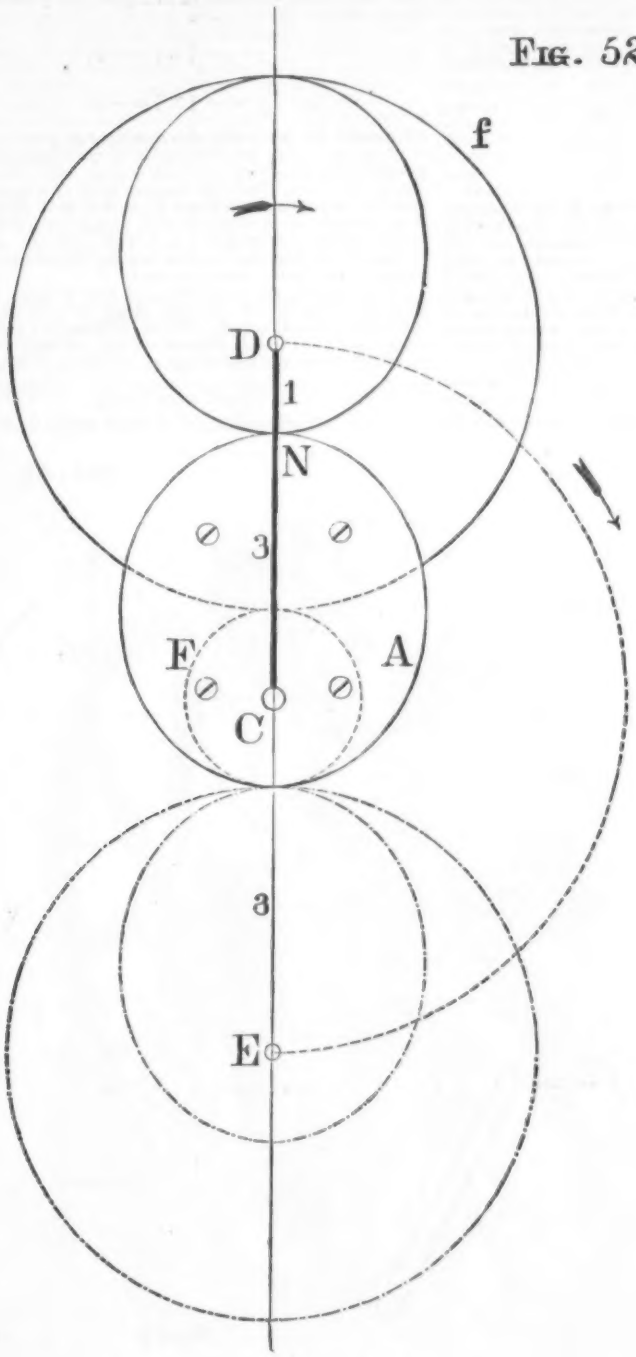
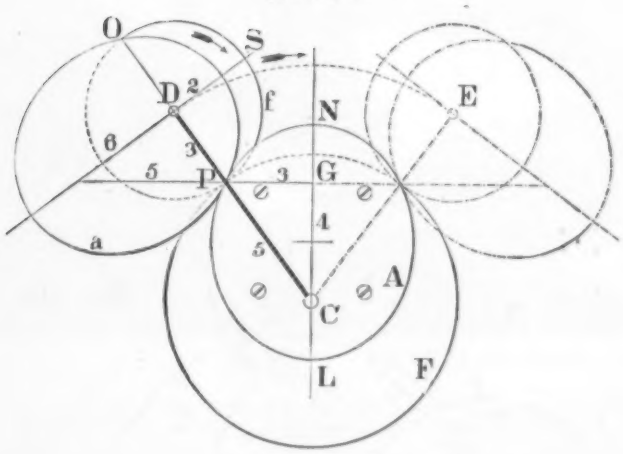


Fig. 53.



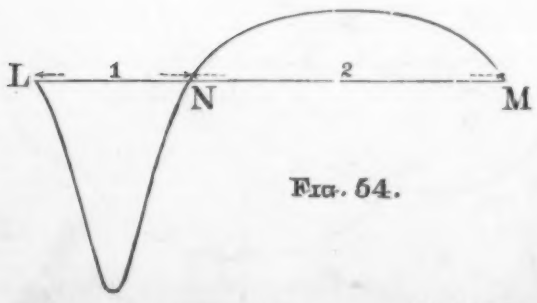


Fig. 54.

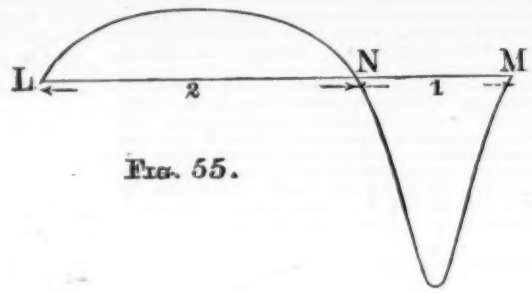


Fig. 55.

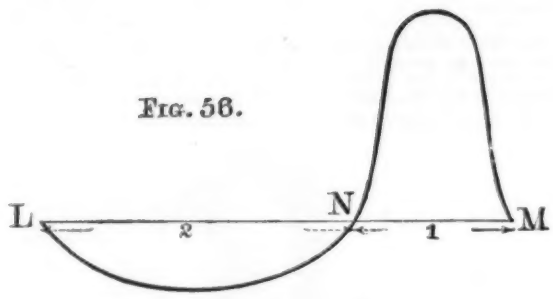


Fig. 56.

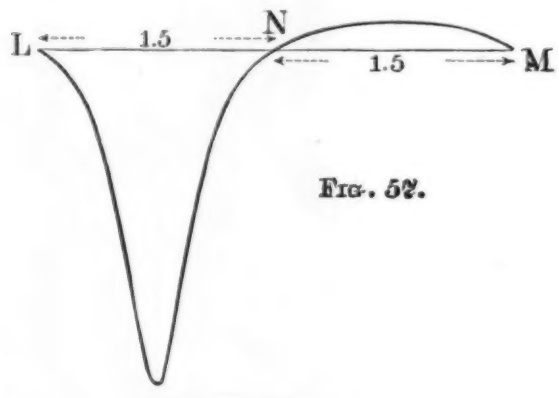


Fig. 57.

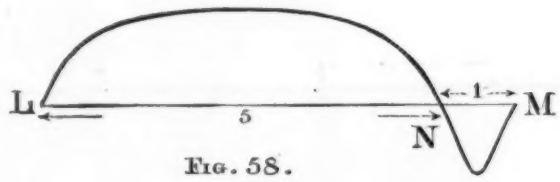


Fig. 58.

Fig. 59.

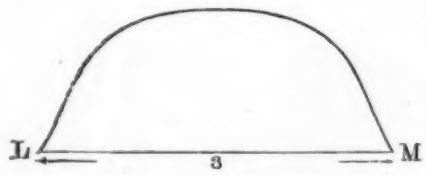
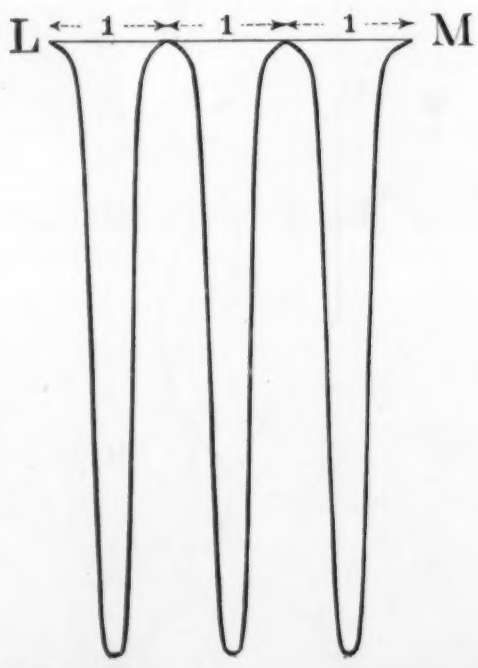


Fig. 60.



PLANETARY WHEEL TRAINS.

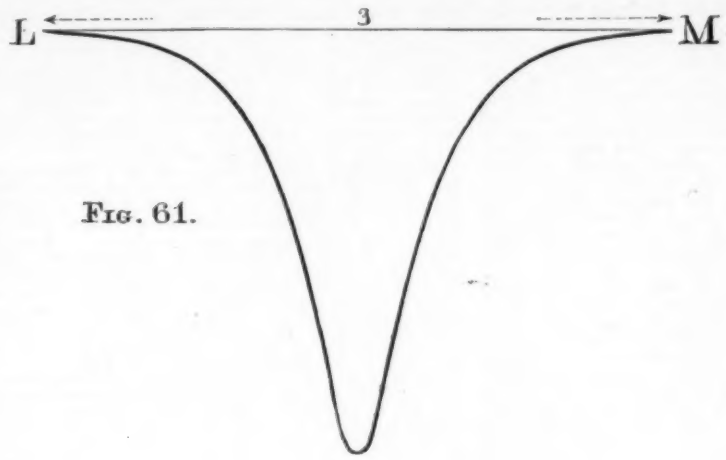


FIG. 61.

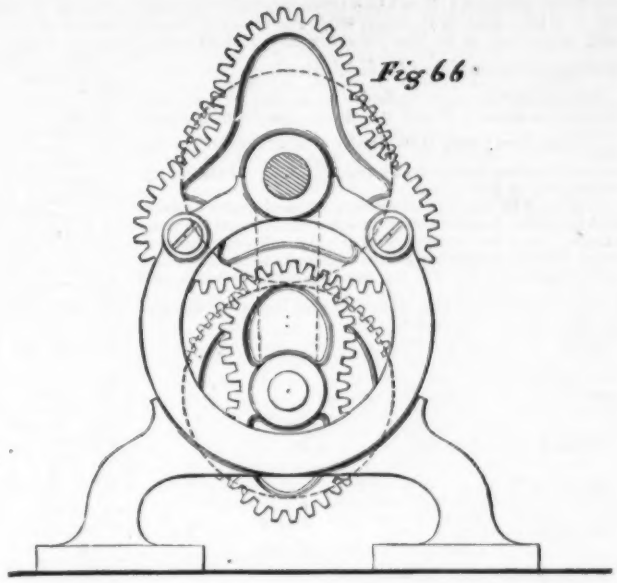


Fig 66

FIG. 62.

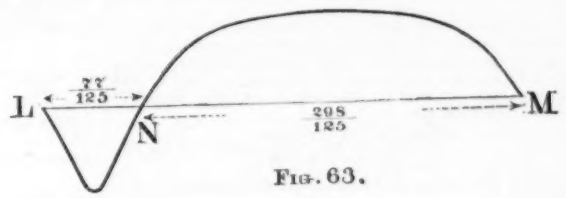


FIG. 63.

FIG. 65

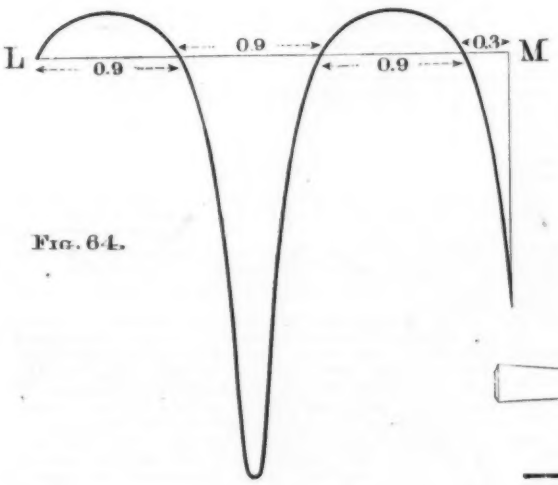
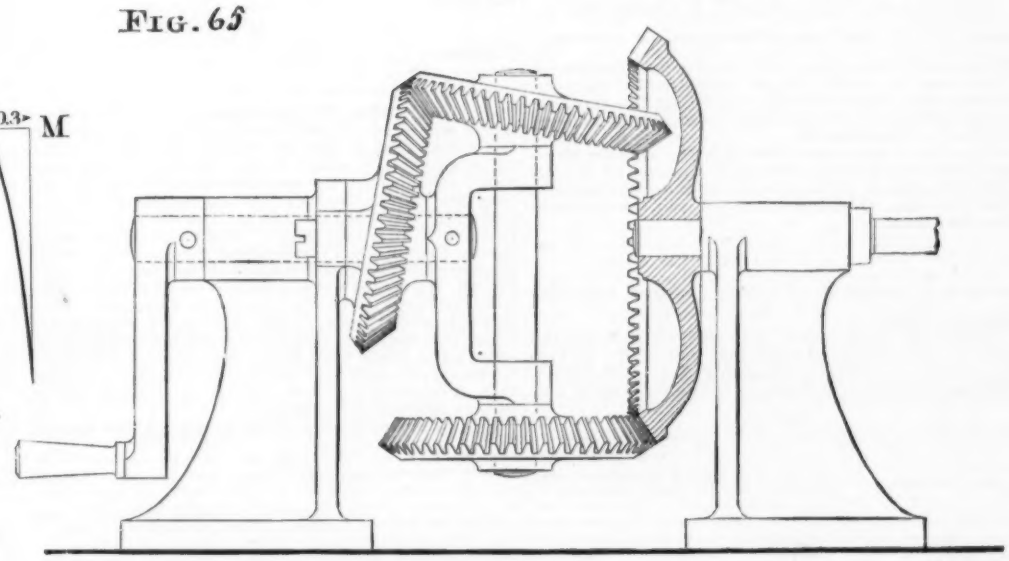


FIG. 64.



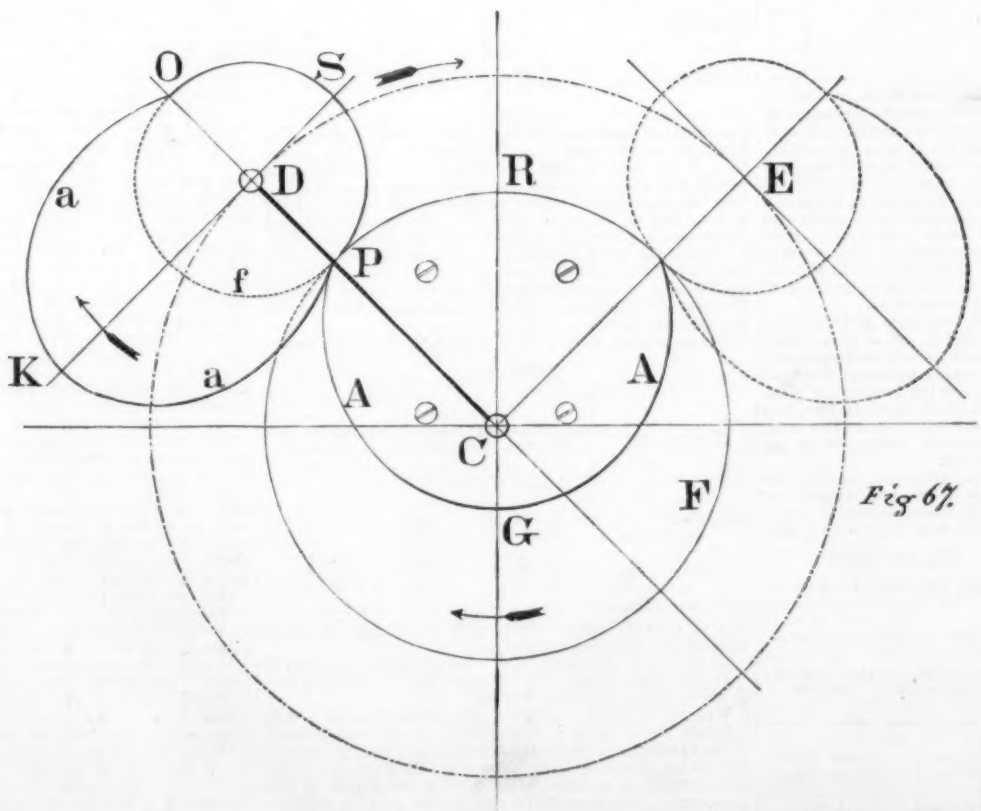


Fig 67.

PLANETARY WHEEL TRAINS.

reach the position C E, while a turns around D through twice P D S, that is through 180°; the result of which will, reasoning as in the previous cases, be to turn F backward through $\frac{71}{750}$ of a revolution.

In a similar manner we find that during the completion of the circuit, F will be driven *forward*, through $\frac{371}{750}$ of a turn; and thus finally F is advanced, in the same direction as the train-arm, $\frac{300}{750} = \frac{2}{5}$ of the entire revolution of the latter.

It is easy to see that this result, of having the positive and negative limits of the velocity ratio equal in magnitude, may be obtained with any ellipse. Let the focus cut the major axis into segments m, n, of which m is the greater: let x = the limiting velocity ratio, and $y = \frac{f}{F}$, the ratio of the diameters of the two circular wheels.

Then $$1 - \frac{m}{n}\,y = x \ldots\ldots\ldots\ldots\ldots\ldots 1.$$

$$1 - \frac{n}{m}\,y = -x;$$

Adding $$2 - y\left(\frac{n}{m} + \frac{m}{n}\right) = 0$$

Whence $$y = \frac{2\,m\,n}{m^2 + n^2}$$

Substituting in 1, $$x = 1 - \frac{n}{m} \times \frac{2\,m\,n}{m^2 + n^2}$$

which gives $$x = \frac{m^2 - n^2}{m^2 + n^2}.$$

It is evident that x must be a proper fraction; and if its value be assigned, this last expression enables us to determine the eccentricity of the ellipse; it is true that we then have two unknown quantities, m and n; but from the above expression we find their ratio, which is all that is needed, viz.,

$$\frac{m}{n} = \sqrt{\frac{1+x}{1-x}},$$ after which the value of y, the ratio of f to F, is readily determined.

From the form of this value of $\frac{m}{n}$, it appears that the value of $\frac{1+x}{1-x}$ must be a perfect square, in order that the required limits x and $-x$ may be *exactly* secured; if it be not, the result will be approximate only; but by extending the decimals in extracting the root, the deviation from the precise figure assigned may be made practically inappreciable.

Thus far we have considered only the case in which one of the *elliptical* wheels is fixed; but one of the circular ones may be fixed instead, and the elliptical sun-wheel left free. The expression for the velocity ratio then becomes:

$$\frac{V'}{v'} = 1 - \frac{F\,a}{f\,A},$$

in which $\frac{F}{f}$ is constant, $\frac{a}{A}$ varying between reciprocal limits as before.

The results which follow from this will not be the same in all cases, as will readily be perceived. In Fig. 48, where F = f, the change amounts substantially to a reversal of the train, as shown by the annexed table, and

Fig. 48.

Fixed sun-wheel.	Revolutions of train-arm.	Revolutions of free sun-wheel.	Limits of velocity ratio.
Elliptical.....	$+\frac{1}{3}$ $+\frac{1}{3}$	$-\frac{1}{3}$ $+\frac{1}{3}$	-2 $+\frac{1}{2}$
Circular.....	$+\frac{1}{2}$ $+\frac{1}{2}$	$+\frac{1}{2}$ $-\frac{1}{2}$	$+1$ -2

perhaps more clearly by the diagrams, Figs. 54 and 55. The ordinates of these curves represent the angular velocities of the driven sun-wheel, the horizontal line LM representing the time occupied by one revolution of the train-arm, of which the velocity is uniform, and the motion from left to right is regarded as positive. The ordinates lie below LM when the follower turns in a direction opposite to that of the train-arm, above it when these directions are the same; and in each case the curve cuts LM at N into segments of which one is twice as great as the other; LN being the less in Fig. 54, which shows the curve for the original arrangement of Fig. 48, the elliptical sun-wheel being fixed.

Since in these two cases the resultant action is an oscillation of the follower through an arc of 120°, which can also be produced by the crank and slotted arm as in Fig. 49, we give in Fig. 56 a velocity diagram for that device drawn to the same scale, for the purpose of comparison; and it is quite evident that though the two combinations are alike in ultimate effect as to the magnitudes and times of the oscillations, they are by no means equivalent in other respects.

Now let us return to Fig. 50; in order to determine the values of the velocity ratio, it is necessary to ascertain the ratio of the segments CL, CN; which is readily done, since PC = 1, PG = 2, PCG = 90°, and PC + PG = LN; from which data we find $\frac{CL}{CN} = \frac{317}{1193}$ very nearly.

We can now construct a table like that for Fig. 48, thus:

Fig. 50.

Fixed sun-wheel.	Revolutions of train-arm.	Revolutions of free sun-wheel.	Limits of velocity ratio.
Elliptical	$+\frac{1}{3}$ $+\frac{1}{3}$	$-\frac{3}{8}$ $+\frac{3}{8}$	$-\frac{3444}{1193}$ $+\frac{317}{1193}$
Circular.....	$+\frac{1}{2}$ $+\frac{1}{2}$	$+\frac{1}{2}$ $-\frac{1}{2}$	$+\frac{1193}{317}$ $-\frac{317}{1193}$

And we observe that something more than a mere reversal of the train is effected by fixing the circular instead of the elliptical sun-wheel. The limits of variation in velocity ratio are changed entirely in value as well as in sign; and although the arcs through which the follower turns remain of the same values, the directions only of the motions being reversed, we note that the times occupied by the forward and the backward rotations are no longer equal, the train-arm now requiring in one instance $\frac{2}{3}$, in the other only $\frac{1}{3}$, of a revolution in order to produce the results that previously required exactly a half revolution each, so that two complete revolutions instead of one are necessary to drive the follower through its entire cycle. This latter fact will be readily seen by looking at the question in this way, viz.: the follower is at rest in the position shown in Fig. 50, the ellipses being in contact at P, and will be so again when O coincides with Q; when this occurs, those two points must lie upon the line of centers, that is to say, upon the center line CD of the train-arm. Now, OD, in order to coincide with DP, must turn around D through 300°, or $\frac{5}{6}$ of a turn, and can receive this motion only by the revolution of DC the train-arm around C; the wheel f, rolling upon F, is made to turn upon its axis with an angular velocity only half that of the train-arm, because f is twice as large as F. Therefore, in order to obtain the required $\frac{5}{6}$ of a rotation, the train-arm must be made to revolve through twice as great an angle, or $\frac{5}{3}$ of a turn; and similarly for the remainder of the cycle. The velocity diagrams for these two cases, on the same scale as the others, are given in Figs. 57 and 58 respectively; the length of LM in the latter diagram being twice as great as in the former, since the train-arm makes two revolutions instead of one, at the same rate of speed.

The diagram Fig. 59 is the velocity curve for the original arrangement of Fig. 51, the elliptical wheel A

Fig. 51.

Fixed sun-wheel.	Revolutions of train-arm.	Revolutions of free sun-wheel.	Limits of velocity ratio.
Elliptical.....	$+\frac{1}{3}$ $+\frac{1}{3}$	$+\frac{1}{3}$ $+\frac{1}{3}$	0 $+\infty$
Circular.....	$+\frac{1}{2}$ $+\frac{1}{2}$	-1 -1	0 -8

being fixed. When F is fixed instead of A, it is clear that A will be at rest when the train-arm is in the position CD as shown, and will be so again when a has made one rotation about D, that is to say, when f has rolled one-third of the way around F, bringing the train-arm into the position CH, the maximum velocity being acquired when the arm reaches the intermediate position CG bisecting DCH. Thus there are three instants of rest in each revolution of the train-arm, which accounts for the three branches of the velocity curve, Fig. 60. In regard to the ultimate result of the action, it will be noted that while CD moves forward to CE, a half revolution, f and a turn one and one-half times about D, which axial motion, the ellipses being necessarily alike, would turn A also one and one-half times backward; for each half revolution of the train-arm, then, A makes a complete rotation in the opposite direction, as given in the table.

Figs. 61 and 62 are the curves for Fig. 52, the first on

Fig. 52.

Fixed sun-wheel.	Revolutions of train-arm.	Revolutions of free sun-wheel.	Limits of velocity ratio.
Elliptical	$+\frac{1}{2}$ $+1$	-1 -1	-8 0
Circular.....	$+\frac{1}{2}$ $+\frac{1}{2}$	$+1$ $+1$	$+\infty$ 0

the supposition that A is fixed, the second when F is fixed, as in the previous illustrations. In the latter case, it is obvious that, starting from a position in which A is at rest, f must roll three times around F before the same phase will recur; hence LM is three times as long in Fig. 62 as in Fig. 61. This motion of the train-arm would carry A with it at the same rate, were it not for the axial motion of a, which by reason of the equality of the ellipses tends to turn A once backward in the same time; consequently, for every three turns of the arm, the follower makes two complete rotations in the same direction.

We come now to Fig. 53, in which the limiting values

Fig. 53.

Fixed sun-wheel.	Revolutions of train-arm.	Revolutions of free sun-wheel.	Limits of velocity ratio.
Elliptical.....	$+\frac{317}{1193}$ $+\frac{317}{1193}$	$-\frac{317}{1193}$ $+\frac{317}{1193}$	$-\frac{1}{3}$ $+\frac{1}{3}$
Circular	$+\frac{1}{2}$ $+\frac{1}{2}$	$+\frac{317}{317}$ $-\frac{317}{317}$	$+1$ -1

of the velocity ratio, when A is fixed, are of equal magnitudes but contrary signs.

In this case, dividing LM into 375 parts, the curve cuts it at N into segments, of which LN = 77, NM = 298, in the velocity diagram, Fig. 63.

When F is fixed, it is clear that f will make a half rotation about its axis, in rolling $\frac{1}{12}$ of the way around F; and starting from one position in which A is stationary, as for instance that shown in full lines in Fig. 53, another will be reached after $\frac{1}{12}$ of a revolution of the train-arm. Consequently the curve in the velocity diagram, Fig. 64, cuts LM at three points N, R, S, the distances LN, NR, RS, being equal to each other and to $\frac{1}{12}$ of LM. Taking CD as the initial position of the train-arm, the axal rotation of a during the first $\frac{1}{12}$ of a revolution would move A backward $\frac{37}{1193}$ of a turn, which therefore is to be subtracted from the $\frac{1}{12}$ forward due to the orbital motion, leaving an actual advance of A equal to $\frac{81}{1193}$. During the next $\frac{1}{12}$ of a revolution, the motion of A is $\frac{1}{12} - \frac{317}{1193} = -\frac{317}{1193}$, and so on alternately for each corresponding fraction of the revolution; A, consequently, makes ultimately $\frac{300}{1193}$, or $\frac{2}{5}$ of a turn backward for each $\frac{2}{3}$ of a revolution of the train-arm from the position CD, as given in the table.

Since in these velocity diagrams the abscissas represent time, and the ordinates represent angular velocity, the areas represent space traversed in a circular arc. They are therefore proportional to the numbers given in the small tables, under the head of "Revs. of Free Sun-Wheel." Thus, in Figs. 54 and 55, the areas above and below the line L M are equal to each other, each representing one-third of a rotation of the follower; these motions being in opposite directions, their algebraical sum is zero, as it should be, since after one revolution of the train-arm the follower has returned to its original position. In Figs. 57 and 58, the smaller area is in each case equal to $\frac{1}{7}$ of the greater, and their algebraical sum is −1 in the former diagram, and +1 in the latter; which again accords with the stated action of the train, the follower making alternately one-sixth of a turn in one direction and seven-sixths in the other. Again, the difference between the areas of the greater and lesser curves in either of these last two diagrams, representing a complete rotation, is equal to three times the area of either curve in the first two, since the scales of ordinates and abscissas are the same, and so on for all the other diagrams.

The construction of mechanism of this kind is not, of course, limited by the necessity of employing spur wheels. But we have confined our illustrations mainly to those devices in which no others are used, because they are more common, and their action perhaps more readily traced by examination of the figures. As has been stated, however, screw wheels or skew-bevel wheels may be used in trains whose velocity ratio is constant; also common conical wheels, a good example of which, combining both the differential and the cumulative principles, was given in Supplement No. 134; and the well-known differential pulleys are familiar illustrations of the application of wrapping connectors in similar combinations. But even in the case of a varying velocity ratio, the construction of a planetary train does not prevent the introduction of rotations about axes which are not parallel. Elliptical bevel wheels (for the construction of which see Supplement No. 141) may be employed in a planetary train; an illustration of this is given in Fig. 65, one pair being ordinary conical wheels.

Now it will be seen at once that such trains may be made cumulative as well as differential. But it will also be apparent on a little study that no advantage would be gained thereby; for the velocity ratios have the limits,

$$\frac{V'}{v'} = 1 + \frac{A\,f}{a\,F},\ \frac{V'}{v'} = 1 + \frac{a\,f}{A\,F},$$

if we designate by A, a, the greatest and least radii of the two ellipses; these values are both positive, and their ratio can be expressed in integral terms. Consequently, the same variation can be at once produced by a single pair of elliptical wheels turning on fixed axes, without the complication of any planetary device whatever.

So far as the use of elliptical wheels then is concerned, the differential combinations only need be considered, at least in four-wheel trains with one sun stationary. Attention has been confined to these alone, as they suffice to exhibit with clearness the possibility and the manner of producing varied motion by the internal construction of a complete planetary train, composed of non-circular wheels, to which we have never met with an allusion. But whether this field of study be new, as we deem it, or not, it can be extended far beyond the limits thus far explored. One pair only of the wheels has been made elliptical; but clearly the second pair may also be made of the same form; that is, they may be ellipses, though, so long as the major axes are of the same length, the eccentricities of the two pairs may be different; and again, supposing, for instance, one pair to have the extremities of their major axes in contact, the other pair may be set in any phase of their mutual action. This of itself would give a much wider range; but yet, again, the fundamental principle is not confined to the application of the ellipse alone; for if any two curves are capable of continuous rotation in rolling contact about fixed axes, one of them may be made stationary, and the other will roll around it without change in the distance between the original axes of rotation. We may, therefore, employ one pair of wheels with any numbers of lobes, the other pair either being circular, as in Fig. 66, or having the same or any other numbers of lobes. In connection with which latter arrangement it may be pointed out that it is possible in some cases to balance the mechanism by using two opposite pairs of planet-wheels, as was done with circular wheels in Bogardus's Horse-Power. In order to admit of this, each sun-wheel must have an even number of similar lobes, though not necessarily the same number; and the two planets which engage with either of them must of course be alike and set in the same phase of action, but they need not be like the pair which engages with the other sun-wheel.

And further, it is to be recollected that neither of the sun-wheels need be stationary: in these trains, just as well as in those composed wholly of circular wheels, we may drive one sun-wheel and the train-arm by independent means, and in this way a still wider range of variations becomes possible.

One or more *instants* of rest during each revolution of the train-arm have been produced by combinations above mentioned; but in this respect also we may go further, and obtain an intermittent motion; a definite *period* of rest succeeding a variable rotation of the follower. The method of accomplishing this result is illustrated in Fig. 67; the arc P Q of the fixed sun-wheel A is circular, and its length is to that of the circular arc P S O of a, in the inverse ratio of the radii C P, P D, which are also the radii of the circular pair F, f. This being the case, it is apparent that F will will remain stationary while the train-arm moves from the position C D to the position C E. In the particular combination here given, P R Q is a quadrant and P S O a semicircle, whence P C = 2 P D, P C R = 45°, P C G = 135°, and P D K = 90°. We have now to find two curves, P G and P K, capable of moving in rolling

contact about C and D as fixed axes (the mode of constructing these, which does not affect the principles herein discussed, will be explained in a subsequent article); then K O is made symmetrical with K P, and G Q with G P, which completes the non-circular wheels, in so far as their pitch lines are concerned.

The wheel, F, is at rest, as stated, during one-fourth of the revolution of the train-arm; during the other three-fourths (which tends to carry F forward at the same rate and through the same angle), *a* and *f* make a half rotation, which would give F a quarter turn backward: the total effect, then, is that the follower makes a half turn forward for each revolution of the arm.

Such intermittent rotatory motions are usually produced by the use of mutilated circular wheels; the teeth being removed from a portion or portions of the circumference of the driver. To this device there is an objection arising from the fact that the velocities are in general uniform, so that there is a shock when the teeth first come into gear; and the abrupt cessation of the follower's motion is liable to cause trouble at high speeds, on account of the momentum of the moving parts. Of course, it may be that in some cases the uniform speed while in motion is required by the nature of the objects to be accomplished; but in others again it may be that the *definite period of rest*, alternating with a definite amount of angular motion, satisfy the requirements, the variable rate of the rotation being of no consequence. In the latter circumstances it would seem that the planetary arrangement of Fig. 68 could be used with advantage, since the follower starts gradually and comes to rest gradually; and it at least appears a rather curious piece of mechanism, producing an intermittent motion of the follower under the seemingly anomalous condition that its teeth at all times engage with those of a continuously rotating wheel. But it is not within the scope of this paper to discuss the practical applications which may be made of these interesting and possibly novel methods of modifying motion. That such applications can be made, and to good advantage, there can be little doubt, for in a general way we think it safe to say that, in view of the infinite variety and complexity of motions required in mechanism for industrial purposes, no new mechanical movement can be devised which will not in some way and at some time be found capable of producing useful results; what one contrives, with no definite end is object, may prove to be the very thing for which another who has a purpose to accomplish has sought without success; and in this belief we ground the hope that we have not been plowing a wholly barren field.

BENJAMIN B. HOTCHKISS.

THE death of Mr. Benj. B. Hotchkiss removes from the department of warlike invention one of its most notable representatives. His remarkable success in this special field was the result of a rare combination of inventive ingenuity, business ability, and diplomatic skill. There was a strain of Indian in his blood, but it was hard to find it in his character, which was that of the typical Yankee of his native Connecticut—shrewd, inventive, industrious, and energetic, and at the same time fond, in his way, of good company and good fellowship. Mr. Hotchkiss became well known to our artillerists during the war as the inventor and manufacturer of the shell which bears his name. After the war he invented the Hotchkiss magazine gun, parting with his interest in it, however, to devote his attention to the Hotchkiss revolving cannon, which he has introduced with such success abroad. He enjoyed the advantage of the mechanical training he received in early life as a machinist in the Sharps rifle factory, and later on in the employ of Col. Samuel Colt, whom he assisted in perfecting the revolving principle in pistols. Twenty-five years ago he became a resident of New York, and during the draft riots was in charge of the arsenal. Mr. Hotchkiss was president of the Congress Park and the Empire Spring Company, in Saratoga, and did a great deal toward beautifying the park. His gun factory was situated in Paris, and he was about to found another in England. He died at the comparatively early age of 55, of a stroke of apoplexy, to which his full habit of body predisposed him. He had had a previous paralytic attack last summer, but he came to this country to visit his father, who lives in Connecticut, and is 90 years of age; and while here his health rapidly improved, and his physicians told him that he would recover, provided he took more rest and worked less. He returned to Paris in September, and to the work which resulted in his death. Mr. Hotchkiss was married twice, the second time to a New York lady, who survives him, and who proved a most valuable assistant to him in his labors. He was a most genial and hospitable gentleman, and the news of his death will be received with great regret by his numerous friends in our services. He leaves an ample fortune, which we see is estimated as high as five millions of dollars. It is a misfortune that such men should be driven abroad to seek that field for their energies which would not be lacking here if there were any proper appreciation of the need we have for their services.—*Army and Navy Journal.*

[AMERICAN JOURNAL OF SCIENCE.]

BENJAMIN SILLIMAN.

BENJAMIN SILLIMAN, son of Benjamin Silliman the founder of this journal, and long one of its editors, died at New Haven, Conn., on the 14th of January, 1885.

Mr. Silliman was born in New Haven, on the 4th of December, 1816. His mother, Harriet Trumbull, was the daughter of Jonathan Trumbull, Governor of the State of Connecticut from 1798 to 1809. Surrounded from his childhood by an atmosphere of science, he early made acquisitions in chemistry and mineralogy, and exhibited also much interest in the practical arts and mechanics. He entered Yale College in August, 1833, and was graduated four years later, with the class of 1837, a class which included an unusual number of men who have since had prominent positions in the country. Before graduation, in the summer of 1836, he began his mining explorations in a visit with his father to the gold region of Virginia, a report on which, over thirty pages in length, by his father, is contained in volume xxxii. of this journal.

After leaving college, in 1837, he became his father's assistant in chemistry and his other departments, a position just then left vacant by the resignation of Mr. J. D. Dana, who had received an appointment to the department of Geology and Mineralogy in the Wilkes Exploring Expedition.

The laboratory gave him opportunities for experiment and study of which he assiduously availed himself; and by the year 1842 he had, without outside help, of which the country afforded then almost nothing, acquired sufficient knowledge of general and analytical chemistry and mineralogy to enable him to instruct others on these subjects, and he received a few students in what would now be called very narrow quarters in the old laboratory of the College. One of the earliest of these private pupils was Mr. John P. Norton, afterward Mr. Silliman's associate, who studied with him in 1842 and 1843, and later spent two years in laboratories in Edinburgh and Utrecht. Another was Mr. T. Sterry Hunt, who commenced his studies with Mr. Silliman in 1845—then a young man of 20 years, having some knowledge of chemistry and a zeal for science, which he brought with him from his home in Norwich (Connecticut), that commended him strongly to both the Sillimans.

This was the commencement of work in advanced chemistry in the College; but it was outside of the College curriculum, and had no recognition from the College authorities. In 1846 a memoir to the Corporation by himself, adopted and seconded by his father, urging the official recognition and organization of a new department of advanced science, led to the establishment of the "Department of Philosophy and the Arts." The "School of Applied Chemistry" was organized under this department, and placed in the charge of Mr. Silliman, as Professor of Chemistry applied to the Arts, and Mr. John P. Norton, as Professor of Agricultural Chemistry. The school took possession of the old Presidential residence on the College ground, which the professors, without salaries from the College, and at their own expense, fitted up for the purpose—by the permission of College authorities, but without the privilege of using the building free of rent. Thus Mr. Silliman, through his zeal and energy, early made a strong impression on the system of education at Yale; and the College had, almost unknowingly to itself, taken an important step toward the rank and character of a university.

The school was successful from the beginning, and the enthusiasm of the professors called out equal enthusiasm in the pupils. It was the germ from which proceeded later, under an enlarged faculty—though still an unpaid, self-sacrificing faculty—the Yale Scientific School; and this prepared the way for the greater expansion under the generous gifts of Mr. Sheffield. Among the six students of the year 1847, the first after the new organization, were three, G. J. Brush, S. W. Johnson, and Wm. H. Brewer, who later became professors in the Yale Scientific School, and are still in active service. Mr. Silliman's connection with the Scientific School continued until 1869, but his instruction was interrupted by his residence in Louisville mentioned below, and to a greater or less degree after his return to New Haven by duties in other directions.

In 1838, Mr. Silliman became associated with his father in the editorship of the *American Journal of Science and Arts*, the *Journal* then in its twenty-first year and Mr. Silliman in his twenty-second. This arrangement continued until the close of 1845, when the first series of fifty volumes was ended, after which Mr. James D. Dana was associated with Mr. Silliman in the editorial duties. Up to the present time, 1885, his name has stood among those of the editors of the *Journal* now for nearly half a century.

In the winter of 1845–46, Mr. Silliman gave a course of lectures on Agricultural Chemistry in New Orleans upon the invitation of leading commercial and professional men in that city. In 1849 he received the appointment of Professor of Medical Chemistry and Toxicology in the Medical College at Louisville, Kentucky, which chair he occupied for five years. Louisville became for the time his place of residence. He relinquished this position in 1854 to enter upon instruction in the Academic and Medical departments of Yale College, his father's resignation having left the place vacant. His position as Professor in General and Applied Chemistry in the Academic College he resigned in 1870, but retained his connection with the Medical School until his death.

In 1851 Mr. Silliman accompanied his father on the latter's second visit to Europe. During the time abroad the party visited England, and from there traveled through France to Italy and Sicily. On the return some time was spent in Switzerland and Germany. The journey was a profitable one in many ways. The former European tour of his father, in 1805–6, had been cut short by war, which compelled a speedy retreat after a brief time in Holland, and it was a special delight to him now to visit regions of volcanoes and glaciers, which had been subjects of eloquent lectures by him for so many years, and to see face to face the men whose names he had so often quoted, and so long honored—Lyell and Murchison in England, Brongniart, Milne-Edwards, and Elie de Beaumont in Paris, Marignac and De la Rive in Geneva, Humboldt, Rose, Liebig, and others in Germany; and in this pleasure his son shared most profoundly.

In 1853 Mr. Silliman had charge of the Chemical, Mineralogical, and Geological department of the Crystal Palace in New York. At this time he edited, in connection with Mr. Charles R. Goodrich, a large illustrated quarto volume entitled the "World of Science, Art, and Industry;" and, in 1854, another similar volume entitled "The Progress of Science and Mechanism."

In March, 1864, he made his first visit to California, where, for about a year, he was engaged in the professional work of examining and reporting on mines. His mining explorations at this time were extended into Arizona; and one of the volumes of this Journal for 1866 contains an account by him of his trip to the Mojave desert, Fort Mojave, and the San Francisco mining district. This visit covered the period of his father's death at New Haven, which occurred in November of that year. A second visit to the Pacific States, for a similar purpose, was made by him in the year 1867, and still another in 1872; and after 1872, his journeyings as a mining expert carried him over nearly all the rest of the Rocky Mountain region within the limits of the United States.

Mr. Silliman's scientific publications are numerous, and cover a wide field. In 1846, his father's work on chemistry having been long out of print, he published his "First Principles of Chemistry." The work had many excellent features, was highly valued in the country, and met with great success, more than fifty thousand copies of the three editions (1846–53) having been sold. In the part of the work on Organic Chemistry he had the assistance of Dr. T. Sterry Hunt. About ten years later, in 1858, appeared another work, of somewhat similar nature, entitled the "First Principles of Physics or Natural Philosophy;" a second edition of it was published in 1860. For the work the author modestly claimed, in his preface, only the credit that "belongs to a faithful digest and compilation from the best authorities in modern science." The volume contained a vast amount of matter, well arranged for instruction, and for many years it was the best known of physical text-books in the country.

Mr. Silliman's papers in this Journal are more than fifty in number, and embrace a wide range of subjects. The larger part are descriptions of minerals, more especially from the chemical side, and among the papers are many of prominent interest: on the composition of Calcareous Corals (1846); on the new species, Emerald Nickel, from Texas, Pa. (1847); the results of the optical examination of the Micas (1850); on Gay-Lussite from near Ragtown, Nevada (1866), in which the occurrence of this mineral in process of formation is described; on Priceite, a new borate of lime (1873); on Platinum and Iridosmine at the Cherokee Gold Mine, California (1873); Tellurium ores of Colorado (1874); on the occurrence of Gold with scheelite in Idaho (1877); on Jarosite in Arizona (1879); on Vanadates, Chromates, and Tungstates in Arizona (1881); on the Iron Mountain of Durango, Mexico (1882).

In the department of mineralogy he always took an active interest. His opportunities for collection were large, and he accumulated a fine cabinet, which in 1868 was sold to Cornell University, where it bears the name of the Silliman Cabinet. The mineralogical collections of Yale College are indebted to him for various gifts; and through his solicitation of funds the Baron Lederer Collection was secured, in 1843, for the college.

Other papers by him relate to meteoric stones and irons, as those of Burlington, N. Y., Lockport, N. Y., of Texas, of Concord, N. H., Shingle Springs, Cal.; points in geology and physical optics; photographic experiments with the voltaic arc, then a matter of novelty; the illuminating powers of gas, etc.

Professor Silliman delivered one of the addresses on the occasion of the celebration of the Centennial of Chemistry at Northumberland, Pennsylvania, in August, 1874, which took the form of a full list of American Contributions to Chemistry up to the date of the meeting; it extended to one hundred and seventy-six pages, and is a valuable historical work, the result of a vast amount of labor. It contains a complete list of his own papers up to the time of publication.

Mr. Silliman, throughout his life, but especially in the last twenty years, gave a large part of his energies to work in applied science, including the examination of mines, the preparation of reports on questions connected with the chemical arts and manufactures, in which subjects his knowledge was remarkably extensive, expert testimony in courts, and other matters of practical interest. His reports on these subjects have been very numerous, and involved a great amount of work. One of the latest and most important was the report to the National Academy of Sciences, as chairman of a committee appointed by them, on the subject of the use of sorghum as a source of sugar. His position as State Chemist, to which he was appointed in 1869, also gave him much to do in the line of applied chemistry.

Professor Silliman took a personal interest in the municipal affairs of the town of New Haven, and in his early life, between 1845 and 1849, he was a member of the Common Council. He was one of the fifty original members of the National Academy of Sciences, incorporated by Congress in 1863. He was also a member of a number of other scientific societies at home and abroad.

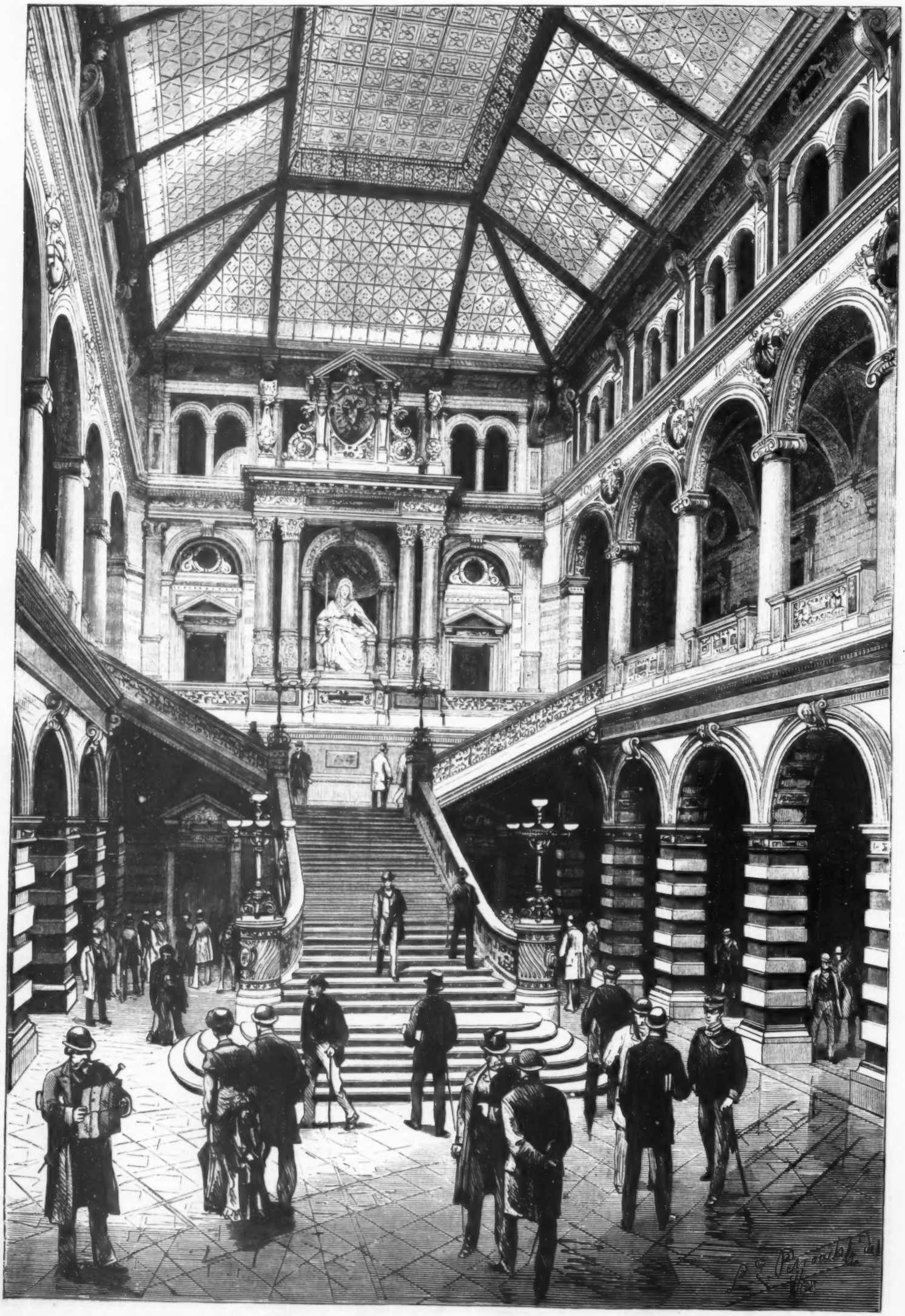
Professor Silliman was a man of exceedingly generous nature and kindly disposition. He was ever cheerful, ever inclined to look upon the bright side of life, hopeful and sanguine of success where others might be discouraged; and if his expectations for himself and others were not always realized, it was largely owing to this element in his character. In society he was most genial, abounding in conversation based on a remarkable range of information on general topics, and with anecdote ready for the entertainment of his guests. Hospitality to friends of the College or to men of science or to those of his own kin and personal intimacy was his delight, and to this some of those present at the recent meeting of the British Association can testify.

During the greater part of his life Mr. Silliman enjoyed excellent health. He had much more than the ordinary amount of vigor, and rarely felt the necessity of considering whether he were able to undertake any labor proposed to him or not. Four years since, after an excursion, late in the autumn of 1880, among the mountains of Pennsylvania, he was prostrated for some weeks with heart disease; and it seemed to his friends for a while that at the best his days of active work were at an end. But in the course of another six months he was off to New Mexico on a visit to the Negretta Mountains (Black Range) in Socorro County; and he returned from the elevated mountain region apparently uninjured by the trip, though conscious of a weakened constitution. His energy was far from giving out; and other excursions were undertaken in the course of the following years, including another trip to New Mexico. His recent illness commenced in October last, with a severe return of his heart complaint, complicated by an attack of pneumonia; and from that time his decline made slow but steady progress—more visible to friends than to himself.

One of the last literary labors which he performed was the preparation, for the National Academy of Sciences, of a memoir of his old friend and colleague at Louisville, Dr. J. Lawrence Smith; and during the last few weeks of his life, when his strength was already largely gone, he gave directions, with a touching degree of affection and interest, for the completion of the medal which was to commemorate the labors of his academic associate. The generous, whole-souled affection for his friends, which characterized his entire life, was never more strongly manifested than during his last days.

The funeral services took place at the College Chapel on the 17th of January.

Professor Silliman was married in May, 1840, to Miss



HALL OF THE NEW PALACE OF JUSTICE, VIENNA.

Susan H. Forbes, of New Haven, eldest child of William J. and Charlotte Root Forbes. Mrs. Silliman died in March, 1878. Four daughters and an only son survive them.

THE CENTRAL HALL IN THE NEW PALACE OF JUSTICE AT VIENNA.

ONE of the most noble of the modern buildings in Vienna is the Palace of Justice, erected after the plans of the architect Alexander von Wielemans, from 1875 to 1882. As the means were almost unlimited in all respects, the architect was not checked in any manner whatever, and could develop his ideas as he desired, and this is probably the reason that the building is of great harmonic beauty. The general arrangement, as well as the details of ornamentation, show all the beauties of the German Renaissance and the early Italian Renaissance. The exterior, as well as the interior, is absolutely pure in style, and both produce very satisfactory effects.

The building was not erected for a single tribunal, but for quite a number of them; as, for instance, the Supreme Court of the Empire, the Supreme Courts for the different States, the courts for the affairs of commerce, agriculture, deeds, etc. Each separate court has numerous halls, offices, record rooms, etc.

The building is erected in the shape of a large square, having an elegant portico in the middle of each facade. The finest room in the entire building, and probably one of the finest halls in Vienna or elsewhere, is the central hall, which is open to the public at all times. The central hall is, at the same time, an arcade court and the building for the staircase. It is covered by an elegant stained-glass roof, which produces a beautiful effect when illuminated by the sun. From this main hall the different departments in the first and second stories are reached. As shown in the annexed cut, taken from the *Illustrirte Zeitung*, the first gallery is supported by arches resting on a number of square rustico columns, and the second gallery is supported by arches on columns of red granite between balustrades of yellowish marble. On the architraves above the second row of columns, a smaller arcade of yellowish marble is erected. The grand staircase, which occupies the greater part of the floor of the hall, first leads upward on the longitudinal axis of the hall, and then branches off, forming wings to the right and left. On the end wall of the hall, in a niche flanked by rich columns and surmounted by an architrave supporting the Renaissance pediment, a statue of Justice is placed. The spandrels, architraves, arches, etc., are very richly ornamented. The hall is 115 ft. long, 73 ft. wide, and 65 ft. high.

ART IN SHEET METAL.

WE present cuts of two of the statues recently made for the New Orleans Exposition, and which are now placed over the principal entrance to the main building. These statues are made by Bakewell & Mullins, Salem, O., in light sheet zinc, stamped and hammered, and are quite a new departure in this class of work. The group is a copy of the allegorical figure representing America at the base of the Albert Memorial, London, and is probably the most pretentious work ever attempted in this material. The base of the group is 11 × 13 ft. square, and to the top of the highest point it is 14 ft. from the base. This group stands just over the main entrance to the exposition, in a niche in the Mansard roof; while just below it, in the niche in the side of the building, and immediately on the side of the entrance, are also sheet zinc statues of Washington and Columbus. These statues are each 9 ft. high.

AMERICA—SHEET ZINC STATUARY AT THE N. O. EXHIBITION.

SHEET ZINC STATUE OF COLUMBUS AT THE N. O. EXHIBITION.

THE INTENSIFICATION OF GELATINE PLATES.

By ARNOLD SPILLER.

NOTWITHSTANDING the fact that a good deal of attention has been given to the subject of intensifiers, but few photographers are satisfied with the results obtainable with the mercury methods. For my own part, I think that a perfect intensifier for gelatine plates as compared with the silver redeveloper for collodion films does not exist; yet there are several processes, if used with care, that answer well for most purposes, and perfectly in a few cases. It will, no doubt, be of interest to some of the readers to explain here the difference between the silver solution acting with collodion film and the mercury with gelatine.

In the collodion film the image is on the extreme surface, and the particles of silver on the film attract the crystalline silver precipitate which gradually separates out from the depositing solution. In the high lights, where there is a greater conglomeration of silver particles, a larger proportion of metallic crystals are deposited, because the attractive force there is greater. Thus in the intensification of a collodion film the second deposit is in exactly the same proportion as the first, and therefore the delicate gradation of the original image is perfectly preserved after the process of intensification. In the treatment of a gelatine plate with the mercury intensifier the effect is very different, for the image is not only on the extreme surface, but in the denser parts the deposit is situated throughout the thickness of the film. When treated with the mercury solution, the half-tones and details in the shadows of the negative are at once increased to double their original density, while only the surface of the deposit in the high-lights is attacked; therefore the increase in density of the latter is not more than perhaps twenty or thirty per cent., supposing that the negative under treatment only requires a moderate amount of intensification. In such a case, the image greatly loses its brilliant contrast or, technically speaking, a general "flatness" in the resulting photographs is noticeable. This tendency of the mercury intensifier to produce "flatness" may, in some few exceptional instances, be turned to good account, as when a negative possesses too much contrast, but requires a slight strengthening of the image. There is still another example where the mercury solution will, if employed, yield results well nigh perfect—I refer to the intensification of very thin images, as are frequently produced with highly sensitive commercial plates. In this latter case the silver deposit should be subjected to the action of the mercury till the entire image is attacked—often a matter of seven to ten minutes—when, of course, the negative preserves its original delicate gradation after the process of intensification. By mercurial intensification I mean the process of bleaching the silver deposit with a mercuric salt, and then treating with some compound capable of blackening the image, such as ammonia, sulphureted hydrogen, sulphite of soda, or ferrous oxalate. The effect of mercuric chloride (the salt usually used) on the silver image is to convert the latter into silver chloride, and, at the same time, to deposit locally mercurous chloride; thus the bleached image consists of chloride of silver and mercurous chloride. In the process of blackening it is generally only the latter that is affected, *e. g.*, ammonia forms the black amido-chloride of mercury; while, again, sulphite of soda reduces the mercury salt to the metallic state. With sulphureted hydrogen, or sulphide of ammonium, both the chlorides in the image are converted into the corresponding sulphides, and also ferrous-oxalate reduces the two chlorides to the metallic state.

When the process of reduction by sulphite of soda or ferrous oxalate is employed, it is possible to obtain almost any amount of intensity, and thus perfect printing negatives may be obtained from mere phantom images. To obtain such results it is only necessary to repeat the process of intensification a sufficient number of times till the desired intensity is produced. The negative, after being thoroughly washed from the sulphite of soda or ferrous oxalate reducing solution, is plunged directly into the mercuric solution, and the process proceeded with as usual.

There is one great defect always met with in mercurial intensification, more especially when ferrous oxalate or alkaline sulphide is used in the after treatment; I refer to the staining of the shadows due to the mercuric salt combining with the gelatine of the film to form an insoluble compound, which is afterward rendered visible by conversion into sulphide or metallic mercury. No doubt the fading of mercurial intensified negatives is due in a great measure to the spontaneous decomposition of this organic mercury compound; also to the presence of the latter, together with the reduction of silver chloride, may be due the increase of intensity of negatives after exposure of some hours to light during printing. It is thus, I think, very evident that some method of preventing the formation of this organic compound should be employed; and I am glad to say that I have discovered a suitable means of carrying out the desired end. It is a well-known fact that free acids act as powerful restrainers in preventing the combination of metallic salts with organic substances; as, for example, the use of citric acid in hindering the formation of albuminate of silver in sensitized albumenized paper. In the same way, I find that hydrochloric acid prevents the formation of the gelatino-mercury compound. In proof of this assertion, I will cite here an illustrative experiment. An ordinary gelatine negative was cut in half, one piece was treated with the usual neutral mercuric solution, and the other was immersed in a similar solution, but containing a small proportion of hydrochloric acid; both films were then thoroughly washed in the same dish.

The two plates were next cut up into three, and one piece from each was treated with solutions of ferrous oxalate, ammonium sulphide, and dilute ammonia respectively. On examination it was found that while all the films that had been immersed in the acid mercury bath presented beautifully brilliant negatives and quite colorless in the shadows, those pieces from the neutral bath were more or less stained. I should mention that the alkaline sulphide solution developed the most stain, and was of a very non-actinic brown tint; ferrous oxalate yielded a less conspicuous gray deposit, while the ammonia gave the least objectionable result. It was found, however, that the ammonia-treated film

turned quite brown on after treatment with the sulphide solution, proving that the ammonia did not remove part of the mercury, but the latter remained to a certain extent *in embryo*. For the intensification of gelatine films in which a preliminary treatment with mercuric chloride is required, I recommend the following solution:

Saturated solution of bichloride of mercury	20 ounces.
Hydrochloric acid (strong)	½ drachm.

A larger proportion of the restrainer might be added when treating hard films, but for general purposes the above formula is preferable, as the acid is liable to produce frilling.

Although not generally used, and probably unknown to many, the most perfect method for intensifying gelatine films is that in which a mercury compound is used simply as a carrier for silver, but does not actually exist in the final result. The process to which reference is made depends on the reduction of silver cyanide by a mercurous salt; the film is bleached in a solution of mercuric bromide, and, after slight washing, is immersed in a bath of cyanide of silver dissolved in cyanide of potassium. By the first treatment, the silver image is converted into mercurous and silver bromides, as is illustrated in the following equation:

$$\underset{\text{Mercuric Bromide.}}{HgBr_2} + \underset{\text{Silver.}}{Ag} = \underset{\text{Mercurous Bromide.}}{HgBr} + \underset{\text{Silver Bromide.}}{AgBr}$$

In the second reaction the mercurous bromide reduces the silver cyanide to the metallic state, thus:

$$\underset{\substack{\text{Mercurous}\\\text{Silver Bromide.}}}{HgBr.AgBr} + \underset{\substack{\text{Potassic}\\\text{Silver Cyanide.}}}{AgK(CN)_2} = \underset{\text{Mercuric Cyanide.}}{Hg(CN)_2} + \underset{\text{Potassium Bromide.}}{KBr} + \underset{\substack{\text{Bromide and Metallic}\\\text{Silver.}}}{Ag.AgBr}$$

From the above it will be seen that the intensified image is composed of metallic and bromide of silver, so that should the deposit, after the treatment, be too intense, it can easily be reduced by a bath of dilute hypo, which dissolves the bromide.

The formula which I recommend for intensifying by this process, although possessing little that is novel, may prove of value to many of the readers who have no experience with the method. The following solutions are required:

A.—Bichloride of mercury	1 drachm.
Bromide of potassium	1 "
Water	16 ounces.
B.—Nitrate of silver	1 drachm.
Cyanide of potassium	1½ drachms.
Water	8 ounces.

The commercial cyanide of potassium is quite pure enough for this purpose; but if the pure salt be used, only 1 drachm should be taken. The solution of cyanide should be made at least twenty-four hours before required, and the liquid shaken briskly from time to time, to insure the saturation by the silver. Even after standing for the above period, a large precipitate will remain undissolved.

A negative to be treated by this method is first soaked in A till the image is more or less bleached, according to the amount of intensification required; it is then washed in two or three changes of water, and placed in another dish containing B, and there allowed to remain until the white deposit is blackened throughout the whole film. The latter is finally very thoroughly washed, preferably in running water, for about half an hour, in order to remove every trace of the silver. Negatives treated by this means ought to be permanent, as the cyanide acts like hydrochloric acid in dissolving out every trace of mercury.

In conclusion, I advise the addition of a small proportion of hydrochloric to the mercury bath for all processes in which the chloride *per se* is used; but when expense is no object, the mercuric bromide and silver cyanide is the most satisfactory method for gelatine films.—*Photo. News.*

EMERY WHEELS AND EMERY WHEEL MACHINERY.*

Emery is a mixture of corundum and oxide of iron; corundum itself is alumina, with a little silica. Sapphire and ruby are corundum in its purest form, slightly tinged with iron oxide. In a less pure state corundum is found in many places, and is then valuable only for commercial purposes. The emery beds of most importance are those situated in Turkey and Asia Minor; considerable quantities of emery are found near Smyrna and Ephesus. The material takes its name from Cape Emeri, a promontory in the Isle of Naxos, where there are considerable deposits. In 1871 large beds of corundum were discovered in North Carolina, their existence having been betokened by the presence of numerous water-worn pebbles in the beds of the adjacent rivers. These beds have been worked commercially, and the corundum extracted, crushed, and used for grinding and polishing. Emery is obtained from surface workings, and the presence of the emery is generally indicated by the dark red color of the ground above it. The prospectors strike steel rods sharply into the ground where they expect the existence of emery, and by examining the points of the rods can easily detect its presence. The mineral is broken up into lumps weighing about 1 cwt. each. If hard to break, a fire is lighted around the refractory lump, and on cooling blows are resorted to again. The lumps are then carried to the coast by railway or on muleback, and the material reaches England chiefly as ballast; thus freight is an insignificant item in the cost. The Turkish and Greek governments generally let the right to raise and dispose of the emery to English capitalists. The specific gravity of emery ranges from 3·75 to 4·28, and the color from dark gray to black; there is an impure variety of corundum, blue gray to brown in color. Much of the commercial emery is artificially colored, and is often mixed to a small extent with ground iron slag; some buyers insist upon the adulteration. Analysis of emery shows that it is composed of from 60 to 80 per cent. of alumina, 8 to 33 per cent. of iron oxide, together with a small quantity of lime water and silica. Taking sapphires as a standard at 100, corundum from the Carolina mine has an abrasive power of from 90 to 97, and the best Naxos emery from 40 to 57 only. This would make it appear as if corundum were far superior to emery for grinding purposes. However, this is not the case, on account of the peculiarity of the fracture of the latter. Every grain of emery breaks with a rough conchoidal surface, and presents numerous sharp points, be the lump large or small; even flour emery exhibits this markedly when examined under the microscope. Corundum, on the other hand, although breaking into pieces with many sharp points, exhibits also plain and curved surfaces. It is owing to this that corundum is not more extensively employed in the manufacture of grinding wheels. Thus emery will cut its way into the material operated on; while corundum will grind and tear, and only perform the work in consequence of its being of a harder nature.

The next point to consider is the preparation of emery on its arrival in this country. It is first treated in the emery mills; stone crushers reduce the large lumps to pieces about the size of a hen's egg, and these in turn are reduced in a stamping mill, or are ground in a horizontal revolving mill with cast-iron circular grinding plates. Naturally the life of these plates is not long, and frequent renewals are necessary. The fragments of emery are then passed between chilled cast-iron rolls, and ground or crushed again, then sifted through sieves. During these operations a portion of the emery is separated from the lumps in the form of dust, which collects on the top of beams and other places. This emery dust is all carefully preserved, and, under the name of flour emery, is useful for polishing. Levigation is another process employed for separating the coarse grains from the fine emery. Six cylinders, about three feet high, are ranged in a row, and are in communication with one another at the top by means of metal pipes. Water mixed with emery from the rolls is introduced into the first vessel. The heavy grains sink, while the lighter ones remaining in suspension, pass over into the next vessel. The process is repeated throughout the range, the last vessel containing the finest emery. There are now in this country a fair number of emery mills, but in America the trade is of greater magnitude and more importance. Emery crushers generally manufacture emery cloth as a branch of their business, as also the flour emery. The chief use of flour emery is for making knife polish, of which enormous quantities are sold. By far the largest demand for grain or crushed emery is for the manufacture of emery grinding-wheels, which of late years have become familiar objects in most engineers' shops. Emery wheel-makers in this country do not, as a rule, crush emery. During the last ten years many classes of emery wheels have been introduced.

The emery wheels best known in England now are the "silicate," or "gray" wheel, the "vulcanite," or "black" wheel, "shellac," or "red" wheel, the "union" wheel, and the "tanite" wheel. The silicate wheel was invented by Mr. Frederick Ransome, Assoc. Inst. C. E., who has perfected the method of manufacture. He employed silicate of soda as the base of the wheel; emery wheels were made for some time by the Ransome Patent Stone Company, in conjunction with the artificial stone and grindstone business. The process consists first in the preparation of the silicate of soda. Beach flints, mostly brought over from France, and used in preference to English flints on account of their being associated with less chalk, are placed in a steam-jacketed boiler; caustic soda is added, and steam turned on. After some hours the dissolution of the flints is complete, very little solid residue being left. The liquid is then allowed to settle and run into a tank, where it is evaporated down to a consistency much like that of treacle, but as clear as sherry. This will remain fluid if properly made. Emery of the required degree of fineness is united with this silicate of soda in a mill and a through mixing obtained; this "pug" is then pressed into moulds by hand pressure. The disk produced would naturally harden by itself in time, but in order to save time it is baked, and is then complete and ready for use. The manufacture of black or vulcanite emery wheels requires heavy and costly machinery. The base is India-rubber, oxidized oil, or other similar material. This is intimately mixed with the emery in steam-heated rolls (horizontal hollow cylinders); afterward calendered to exact dimensions, and squeezed into moulds in a powerful hydraulic press. The disks are then cured in the same manner as vulcanized India-rubber goods, after which they are ready for use. What is known as the red wheel is made with shellac as a base, and although the process is now considered old-fashioned, excellent wheels for some classes of work are the result. Shellac is heated in an iron pot; the emery, which has been previously heated, is introduced, and the whole is well mixed by hand with iron spoons. The pug is then put into moulds and squeezed in a hydraulic press; afterward the disks are baked at a low temperature. The tanite and union emery wheels are made in America; the methods employed in their manufacture are kept secret, and jealously guarded. In the tanite wheel a solution of leather, and in the union wheels oxychloride of magnesium, are the binding materials. The tanite wheel has the reputation of being the best made in America.

Emery wheels have been described as circular files which never grow dull. As previously mentioned, the emery grains throughout the wheel retain their cutting power; and if these grains are cemented together with a proper binding material, an emery wheel can be worked until 90 per cent. of its original weight has been worn off. A file is useless before 5 per cent. of its weight has been used up, and when being worked is driven by manual labor at a speed of 90 feet per minute. An emery wheel penetrates without difficulty into the hardest metals, some wheels even cutting chilled iron or hardened steel more easily than soft iron, and it is driven by steam at a peripheral velocity of about one mile per minute. In using emery wheels successfully, it must be borne in mind that as the wheel wears away the revolutions per minute must be increased, so that as nearly as possible the same surface speed may be maintained upon the periphery of the wheel. The economy of emery wheels in the operation of fettling or trimming castings is very marked, and this relates not only to economy in tools, but also in the saving of time. American foundries, and many English ones, are well supplied with emery fettling machines. An emery wheel keeps its size and shape far longer than a grindstone, and very little practice is required to use it successfully. It is a common thing to see a grindstone, 24 in. to 18 in. in diameter, and 18 in. wide, slowly rotating in a trough, while men push and shove their tools against it to make any impression. It has been stated by an eminent firm of engineers in London that an emery disk as a toolgrinder lasts out six four-foot grindstones, and only requires truing once a month, against the weekly truing up of a stone. They calculate the cost of keeping an emery wheel tool grinder in order as one-fifth of that formerly expended upon the maintenance of grindstones, and the time occupied in grinding tools one-half of that formerly required. In grinding tools, if very large quantities of metal have to be removed, it is best to grind them quickly, and to ignore their temper, rehardening them afterward; but if only slight amounts, then the grinding should be gentle, and their temper will not suffer. Carpenters' planes can be ground by an emery wheel with ease after a little practice.

In this country many persons have failed in the use of the emery wheel, owing to insufficient knowledge. Experienced men, who will take many precautions in fixing a lathe or planing machine, will erect an emery machine anyhow, and then allow it to be used by any one. A very simple machine is sufficient, but it must be rigid, on a good foundation, having long bearings protected from dust, and must be so steady when in use as to be absolutely without tremor or vibration. A wheel should be mounted true and between two washers, screwed up moderately tight, never by driving the wheel on to a square spindle with a mallet, and tightening up the nut with a long-handled spanner. Care should be taken to run the wheel so that the nut tends to tighten itself upon the spindle. Attention should be given to keep the emery wheel true. In large factories one man should have charge of all the emery wheels, and should make his rounds at intervals to true the emery wheels with a diamond tool. This tool consists of a small black diamond set in the end of a half-inch steel bar, about eight inches long, fastened on a handle. In truing, the rest is fixed close to the wheel, and on a level with its center. The diamond tool is then held firmly on the rest, and the point is gradually worked backward and forward until the projecting parts are removed and the wheel runs true. The difference in working with a true wheel and one running out of truth can hardly be imagined by those unaccustomed to emery-wheel grinding. In the latter case grinding is a disagreeable duty, and the jar and vibration render the task of holding on the work very irksome. It is not by heavy pressure that the most and quickest grinding will be effected; the article merely requires holding up well and constantly against the wheel. Intelligent users soon get accustomed to feel the bite. The most economical speed for emery wheels is about 4,000 to 5,000 feet of circumference per minute. Some wheels are driven faster than this, and with good results; but, owing to the jar which occurs if the wheel runs out of truth in the slightest degree, and to the necessity of such rigid foundations, a speed of 5,000 feet is seldom exceeded with success. There is, however, no doubt that the faster a wheel is run the more is the work accomplished. Too much pressure on certain classes of emery wheels induces heat; and the melting of the India-rubber or other substance used as the cementing medium produces a glaze upon the cutting surface. By changing the metal being ground, as, for example, copper after iron, this glaze may generally be removed. In the case of wheels made with silicate of soda, or oxychloride of magnesium as the cementing medium, pressure only raises the temperature of the work, and does not injuriously affect the wheel. Experiments have been made with a view of ascertaining the utmost speed at which an emery wheel would run without bursting. But all wheels tried have stood the utmost test applied. On the rare occasions when wheels have burst, the cause has invariably been traced to unsteady bearings, improper adjustment of the wheel in the first instance, or an article being jammed between the wheel and the rest. But it is well known that far fewer accidents arise from the bursting of emery wheels than from the bursting of ordinary grindstones. It must not be forgotten that as different shapes and varieties of steel tools are necessary for different operations upon a lathe or planing machine, so different classes of emery wheels are required for different purposes, and it is the best economy thus to apply them. One class of wheel should be kept for one class of work whenever practicable. Wheels can be made hard or soft, rough or smooth, slow cutting or quick cutting; as a rule, fast cutting wheels have a rough surface, and slow cutting a fine one. As in the case of an ordinary grindstone, the faster a wheel cuts the faster it will wear away. A wheel can be made so hard that after six months' usage no wear to speak of will have taken place; but the amount of work such a wheel would have turned out would be infinitesimal, compared with that which a softer wheel would have done, and the money and time lost in working the hard wheel would have purchased many soft ones.

* From *Iron*. Paper read by Mr. W. O. Roper at a meeting of the students of the Institution of Civil Engineers; awarded a Miller prize.

SLAG CEMENT.

We have on various occasions referred to the ingenious and very successful processes of Mr. Frederick Ransome for the manufacture of cement from blast furnace slag and lime. The discovery, made about twelve years since by Mr. Charles Wood, that slag run from the blast furnace in a melted condition falls into a fine granulated state, removed one of the main objections to its utilization—the great cost attending its reduction to powder by mechanical means. One of the materials composing the Ransome cement is thus obtained ready for use, and being practically a waste product, its cost is nominal, the expense attending its application being limited to handling. By his earlier method the other material employed—chalk or lime—was ground and mixed with the slag, the combination being then calcined, and again ground; from this resulted a cement possessing very high qualities both as regards quickness in setting and strength. Very recently, however, Mr. Ransome, following the same line of investigation, has improved greatly on his former simple process, and he has found that the spent lime from gas works may be employed with results as good as those obtained with lime prepared specially for the purpose. In order, however, to get rid of the sulphur with which the lime is saturated when it leaves the gas purifier, Mr. Ransome resorts to a very simple and efficacious device. He mixes a certain proportion of powdered coal or coke with the slag and lime, and

when this is exposed to the heat of the calcining furnace, the action of the coal or coke converts the sulphate into a sulphide of lime, that is subsequently entirely got rid of by the introduction of a jet of steam which drives off the whole of the sulphur impurities as sulphureted hydrogen, leaving the lime quite pure; this, however, is only one of the recent improvements to which we have referred. A highly important modification is the use of a revolving retort for the calcination of the slag and lime. It is found that after the materials have been thoroughly burned in this manner, they remain in the same fine state of subdivision as when they were placed in the retort, and on being discharged will pass through a sieve of eighty meshes to the inch. The costly process of grinding, which is unavoidable in the ordinary method of manufacture, is thus avoided, while the cement is said to lose none of its useful characteristics in this novel process. Of course this system is equally applicable where fresh lime is employed, instead of the waste material from gas works, only in such a case it is unnecessary to add the powdered coke, or to apply the steam jet. We have referred in general terms to the strength of the cement produced by this method; the following table of comparative tests made with samples of Portland and Ransome cement shows clearly the remarkable qualities possessed by the latter; the samples in each case were one and a half inches square, giving a sectional area of two and a quarter square inches.

Age of Sample.	Portland Cement. Breaking Load.	Ransome Cement. Breaking Load.
	lb.	lb.
2 days.	510	740
3 "	698	870
7 "	818	1,170
12 "	—	1,300
15 "	—	1,330
21 "	—	1,440
28 "	936	—
7 years.	1,327	—

The foregoing figures speak for themselves, and indicate clearly that the Ransome cement possesses striking advantages over Portland, especially as it reaches a strength within a few days which is higher than the Portland after seven years. Very important advantages are also found in the simplicity of manufacture, and the suppression of the final process of the cement manufacturer, that of grinding. The plant used is, therefore, simpler, and involves much less expense in maintenance and labor for the production of a given quantity of cement than is required in the ordinary mode of manufacture. When, in addition to this, it is remembered that waste materials are employed, it will be easily understood why the slag cement can be made for half the cost of Portland, and the commercial importance of Mr. Ransome's process will be readily appreciated.—*Engineering.*

CEMENTS FOR SPECIAL PURPOSES.

THE value of a cement is, first, that it should become a strongly cohering medium between the substances joined; and, second, that it should withstand the action of heat, or any solvent action of water or acids. Cement often fails in regard to the last consideration. For waterproof uses several mixtures are recommended, and the following may be mentioned: one is to mix white lead, red lead, and boiled oil, together with good size, to the consistency of putty; another is powdered resin, one ounce, dissolved in ten ounces of strong ammonia; gelatine, five parts, solution of acid chromate of lime, one part. Exposing the article to sunlight is useful for some purposes. A waterproof paste cement is said to be made by adding to hot starch paste half its weight of turpentine and a small piece of alum. As a cement lining for cisterns, powdered brick two, quicklime two, wood-ashes two, made into a paste, with boiled oil, is recommended. The following are cements for steam and water joints: ground litharge, ten pounds; plaster of Paris, four pounds; yellow ocher, one-half pound; red lead, two pounds; hemp, cut into one-half inch lengths, one-half ounce, mixed with boiled linseed oil to the consistency of putty. White lead, ten parts; black oxide of manganese, three; litharge, one; mix with boiled linseed oil. A cement for joints to resist great heat is made thus: asbestos powder, made into a thick paste, with liquid silicate of soda. For coating acid troughs, a mixture of one part pitch, one part resin, and one part plaster of Paris is melted, and is said to be a good cement coating. Correspondents frequently ask for a good cement for fixing iron bars into stone in lieu of lead, and nothing better is known than a compound of equal parts of sulphur and pitch. A good cement for stoves and ranges is made of fire-clay with a solution of silicate of soda. A glue to resist damp can be prepared with boiled linseed oil and ordinary glue, or by melting one pound of glue in two quarts of skimmed milk; shellac, four ounces; borax, one ounce, boiled in a little water, and concentrated by heat to a paste. A cement to resist white heat may be usefully mentioned here: pulverized clay, four parts; plumbago, two; iron-filings, free from oxide, two; peroxide of manganese, one; borax, one-half; sea-salt, one-half; mix with water to thick paste, use immediately, and heat gradually to a nearly white heat. Many of the cements used which are exposed to great heat fail from the expansion of one or more ingredients in them, and an unequal stress is produced; or the two substances united have unequal rates of expansibility or contractility; the chemical or galvanic action is important. The whole subject of cements has not received the attention it deserves from practical men. Only Portland cement has received anything like scientific notice, and a few experiments upon waterproof, heat-resisting, and other cements would show which cements are the best to use under certain circumstances.—*Building News.*

PAVEMENT OF KANSAS CITY, MO.

MR. WM. B. KNIGHT, the City Engineer of Kansas, Mo., desires us to state that the cost of concrete, quoted at $3.50 to $3.75 per square yard, in his paper on the pavements of Kansas City, published in SUPPLEMENT of Feb. 14, 1885, should have read "concrete in place, $3.50 to $3.75 per cubic yard."—ED. SUPP.

IMPROVED SILK WARPING MACHINE.

WE have pleasure in giving illustrations of two machines especially intended for silk manufacturers, and made by Messrs. Wildigg Bros., engineers and machine makers, Coventry. The machines are intended to replace the old warping mill, than which it will do much better work, and with greater expedition. Further, in the old system with the warping mill as applied for silk it is customary to obtain the leese in half beers or some certain number of ends; and when the warp is unwound from the mill to be wound upon the loom beam, there is a great deal of crossing of the warp threads, which the weaver has to put right every now and then before the part is woven. None of these defects appear in the machines illustrated, although the warping is in sections. To warp in a machine not in sections would involve one bobbin in the warp creel for every end of warp, and would mean a vast deal of material; by warping in sections, the warp is made by warping one length, then beginning again on the fresh part of the beam with the same bobbins, moving them a little to one side. The minder divides his section according to his stripes, if he has any, so that they repeat each other, and with a low material he will arrange to have fewer bobbins to look after; but, generally speaking, 200 to 300 may be taken as the bulk of the work. Each end of the yarn is laid parallel, and each end in its proper leese. There are a few improvements in the warping machine (Fig. 1) that also deserve notice, that render it in fact an automatic machine capable of being attended by an unskilled person.

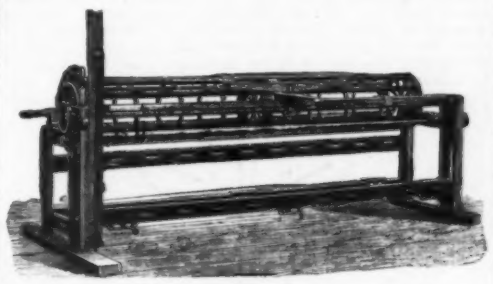


FIG. 1.

The warp reel may be removed when full to the machine (Fig. 2), by which the warp is wound on the loom beam. The yarn creel is not shown; it is placed in front of Fig. 1; the vertical graduated slide to the left of the machine has a screw and a stop motion, and can be arranged to stop the working at any number of yards by putting the stationary stop on the figure desired. By putting it on the 250 yards, when the 250 yards have been wound the movable stop comes in contact with the stationary one and stops the machine. Underneath the thread guide, and attached to it, is a guide screw, which can be put out of connection with the vertical driving screw when required. Such in brief are the main points of the machine. The silk reel, however, has a taper diameter for about nine inches at one end of the reel, this taper is very slight, and the remainder of the reel is parallel.

Supposing the minder is beginning a new reel, she adjusts the stop motion, which is the only thing left to her or her foreman to do, and she commences warping at the foot of the taper part. Of course she attends to the leesings. The thread guide now advances and builds the yarn on the taper, until the knock-off motion acts, and the winding is stopped. The yarn is cut and attached to the quantity of warp on the beam, and the thread guide is moved until the yarn covers a bare part of the reel for about the width of its ribbon. It is then attached to the reel, and the warping goes on as before, the winding being now on the taper part of the yarn. By successive stages the warping is finished, when the reel is taken to the machine (Fig. 2) for the purpose of being wound on to the loom beam. The mode of winding is such that with ordinary care the warp as it passes on to the loom beam has its ends laid evenly and regularly of one length, so much so that the parts where the sections are joined cannot be be seen.

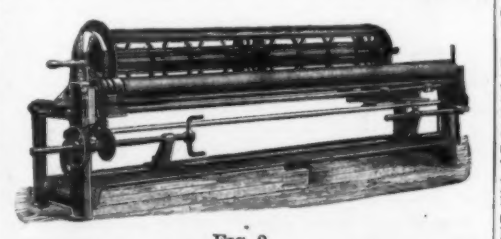


FIG. 2.

One beaming machine, as shown in Fig. 2, it will be understood is sufficient to keep several of the warping machines, Fig. 1, in use.—*Textile Manufacturer.*

LUBRICATING OILS.

AT the recent meeting of the American Association of Mechanical Engineers, Dr. Arvin, the well known chemist of the Standard Oil Co., made some remarks in regard to the character of lubricating oils, which are worthy of careful attention by all who have machinery to care for. The Doctor's remarks were called out by those made by Prof. R. H. Thurston on the subject of bearings and lubrication. Such criticisms upon oil tests, coming as they do from one whose entire business is with oils of various kinds, will strike most of our readers, as they did the members of the society, as being not only valuable, but refreshingly frank and truthful. The Doctor said:

"To a practical man who wants to know what he needs to put upon his engine, the value of 'the coefficient of friction' is extremely low. We know perfectly well that it depends upon many conditions that are difficult to maintain and to understand. Even the wisest admit that there is very little yet found out which throws a practical light upon that subject.

"For instance, we know perfectly well when they decide the coefficient of friction of paraffine oil, on two polished surfaces made to fit perfectly, we gain no light at all on what we need to use on bearings that do not fit equally well or have the same finish. If we are to decide how to construct a bearing, what its proportions should be, how large a segment it should cover, all of these researches would be directly in point. But if we have an engine that runs hot, or a certain construction of bearing that makes it difficult to find a suitable lubricant, these investigations afford us no light whatever, and I think that any engineer will agree with me that, crediting all possible value of researches regarding the coefficient of friction, what we want to know is vastly beyond that.

"For instance, an engineer comes to you and says: 'I was using such a paraffine, and my engine ran cold; I am now using such a paraffine, and it runs hot.' We find on examination that there is no practical difference between the two, but when we come to apply them to a bearing, we find that for some strange reason the two oils did not work alike. When we apply them to spindles, we find that two paraffine oils often bear no relation to each other in their practical behavior. We find that one will run at a much higher temperature, for some obscure reason. We might think it due to its viscosity, but we find by our instruments that it does not depend on that. In some instances, too, the results which we obtain are exceedingly contradictory.

"The Rochester & Pittsburg Railroad Company run their cars with a bearing, the surface of which is composed apparently of lead. There is a very thin film of lead—it appears to be lead—spread over the inner surface of the composition box, which looks as though it might be gun metal. They say they will run an oil on this soft bearing that I know positively fails under similar circumstances, and on the same class of cars, on the Erie, New York Central, and Delaware & Lackawanna—just why, I cannot say for the life of me. I know that that shaft will sink down on that bearing, and yet it runs cold, and runs on a very cheap oil. One of the Standard Oil companies manufactures an oil which is composed largely of a mineral base which is united with a fatty acid. All things considered, that oil has been the most successful for running cold of any oil used on railways. And yet that fails to equal some other cheaper oils on the friction-testing machines. We have had occasion lately to make some comparative tests on fast-running spindles of the Sawyer pattern.

"We have half a dozen oils from Europe and several made in this country. Taking a spindle-frame, and adapting a dynamometer of my own, I expected to find that oils which had the best body would be the best oils for those spindles. I found I did not know anything about it. After having read many papers and listened to a great deal of talk from gentlemen who know a good deal about it, I found that the spindles did not bear out anything that I expected. Now, a spindle that was nicely fitted behaved in one way; but a spindle that was badly fitted behaved very differently. The effect of this was to establish a friction of its own in addition to the friction which we generally speak of as due to the oil itself. If we put on oil that had good body the heat increased very rapidly. Now, we should say at first that that was an objection to that oil. But we found after running them for a short time that the oils that gave us the best results in the economy of power were the ones that produced the most rapid wear. We found that after running constantly at some 6,500 revolutions a minute, it had lost as much as ½ of one gramme in actual weight. When we took another paraffine oil, the wear was not one-half of that, and there seems to be no apparent reason for it.

"I have come to think lately that the question of wear on bearings, as ordinarily found, is one of vastly more importance than the cost of oil. One large mill-owner came to me recently, and said that he wanted an oil for his spindles. He said he did not care what it cost. He said: 'After running some eleven mills for many years, I have discovered that we sustain such great loss by wear due to poor lubrication as to make the mere price of the oil unimportant.'

"When the engines of the Brooklyn Bridge were started, the faulty constructions of the bearings and journals caused rapid heating. I think it was generally believed by the engineers who examined them that the construction was faulty. The main bearings were like those drawn on the board, and the pinching on the sides appears to have been such as described. While watching those bearings quite intently one day, I happened to put my finger on the shaft (which I think measures eleven inches in diameter) at a place where it showed extra pressure on the box, and I found it quite hot, while just an inch and a half from that section the shaft felt cold, showing how great and intense must be the heat generated when the conductivity of such a mass of iron failed to remove it. It seems to me that the conditions and behavior of those journals corresponded with what Prof. Thurston has just described; and the binding in all such cases being simultaneous with an increase of temperature, I am led to wonder if it be not due to expansion by heat rather than to yield in the journal.

"We generally find that where we can use oils of higher viscosity, ordinary machinery bearings run colder. But in some instances of high speed and heavy pressure only thin oils answer at all, and the bearing must be flooded. I believe the engines of the Edison Electric Light Company, which run the dynamos in Pearl Street, are rated 75 horse-power, and run at the rate of 375 revolutions per minute. I am credibly informed that the oil they are using on these engines is the only sort yet found to run cold. This is an oil of about 32 deg. Baume gravity, which is almost as light and fluid as common kerosene, and requires to be supplied constantly. I have come to think that this arranging of a steady current of thin oil is a very desirable plan wherever it can be practically carried out, as in the case of the Sawyer & Rabbeth spindles and nicely finished and fitted bearings of larger dimensions, like those in the machines these gentlemen have devised for testing oils.

"With bearings nicely finished and journals carefully scraped and ground to fit, an abundant and constant supply of thin oil will give the best possible result in keeping the bearing cold and saving power. With such machines you may learn much of the proper proportions of bearings and of the conditions of friction in re-

lation to pressure and speed, and of oils, too, under the exact conditions of these machines, but nothing of the requirements of machinery in common use. Why, these gentlemen think of a journal and bearing as two cylindrical surfaces in perfect contact. It would be more scientific and practical to regard the fit of ordinary bearings like that of a pea in a bushel basket. In many instances one point of contact would be almost too much to expect, and the "body" or viscosity of the oil must make the fit. I know by my own observation that the results obtained in testing heavy lubricating oils on these machines do not correspond with the practical working of these oils on railway axles and other machinery, and any engineer to whom you might supply oils selected from such data would soon come back to you, as the saying is, 'with tears in his fist and his eyes doubled up.' We have been there—both sides.

"The fact is, the most important conditions under which these tests are made are the very ones that can only be maintained under special and unusual circumstances, and are never found in the great mass of machinery that must be lubricated. This makes the frictional tests by special machines worthless as a means of selecting lubricants, and a delusion to those whose opinions of oils are thus founded.

"I believe that the great value of these friction tests, and the machines by which they are made, lies in another direction; for we know that scientific research lies at the root of all industrial progress. But I think we must try an engine oil on an engine, a spindle oil on a spindle, and a wagon grease on a wagon, all as nearly as possible under the ordinary conditions, to learn anything of the real value of the lubricant.

"While speaking of spindle oils, I should have added that I found their bearing parts did not wear bright. I considered their frosted look as indicative of a friction I saw no way of estimating, although it was attended with rapid wear. With oils of a higher viscosity and heavier gravity the bearing surfaces polish like a mirror, even though the friction, judging by the power consumed, is much greater with the more viscous oils. I infer that we cannot judge of the actual friction occasioned by the moving surfaces in contact, while we are unable to estimate separately that friction attributed to the oil itself. For using a thin oil we decrease that one friction so greatly that we cannot note any lesser increase in the other which occasions wear. If it be true that the question of wear is frequently of paramount importance in choosing special oils, then a low coefficient of friction is no measure of value, and our frictional tests are worthless as a means of judging.

"It is frequently said that we have petroleum oils which alone answer all requirements of lubrication. It is not so. I wish it was. I believe practical experience fully proves that in many instances compounded oils are best. Sometimes a thin petroleum oil, with a small portion of animal oil, gives better results. You may find instances where the best petroleum oils do not answer on an engine, when lard oil, or a mixture principally lard oil, keeps the engine cold and is every way satisfactory. This is sometimes the case whether the petroleum be of heavier or lighter gravity than the lard oil. But I am glad to say these are rare instances, where petroleum oils do not answer every requirement."

THE WENHAM LIGHT.

A NEW lamp for obtaining a brilliant and economical light from common gas has recently been devised by Mr. F. H. Wenham, C.E., the inventor of the well-known binocular microscope. Mr. Wenham's name is not unknown in the photographic world; he and Mr. Frith were, we believe, the first to successfully work the wet collodion process in a hot climate when, some thirty years ago, they went on an eight months' pleasure trip up the Nile in a steamer designed and built by Mr. Wenham himself, and obtained a valuable set of photographs of ancient Egyptian temples. Mr. Wenham was one of the pioneers of the gas-engine, and he has distinguished himself in endless ways as an inventor.

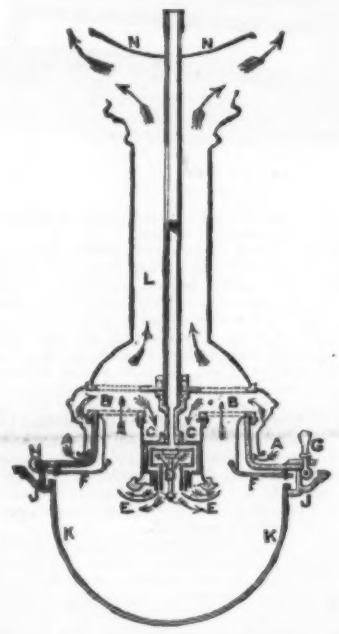
The new gas-light is produced by burning the gas downward, like an inverted sunflower, and the regenerative principle being adopted, by which the waste heat from the flame is employed to heat the air and gas before they reach the burner, and thus to increase the intensity of the illumination; thus converting heat that would otherwise be wasted, into light. Heating the air is of greater importance than the warming of the gas, the volume consumed of the former being about fifteen times greater than that of the latter. The lamp is carefully constructed on strictly scientific principles, with the result that a steady and brilliant annular flame is obtained of surprising steadiness and whiteness. The accompanying diagram represents the lamp in section. The air inlet is at A, and B is the regenerator of thick iron, kept hot by the flame a short distance below. A cylinder, C, conveys the heated air to the burner, D, where it reaches the gas, and the two produce the flame, E. A reflector is placed at F; G is the ring fastener, H the hinge, J the ring to support the glass bowl, K; L the chimney, M the gas-supply pipe, and N the heat disperser. It will be noticed that the otherwise waste heat from the flame is first employed in heating the somewhat massive regenerator, B, and afterward in the channel, L, it warms the gas-pipe, M, the warming of the gas being a secondary consideration. The blown-glass globe inclosing the light is practically air-tight, and is not of the usual heavy cast description, but is thin and light; it is fixed into its metallic ring-carrier by means of a band of asbestos, cemented with silicate of soda.

The gas issues horizontally from apertures round the rim of an Argand burner of a new composition, and it comes immediately into contact with hot air from above, as well as with hot air from below, deflected upward by a disk or "button" near E. If the gas issued as an unbroken sheet from the rim, instead of escaping through a series of holes, the light would not be so strong. To obtain the maximum of luminosity, it is a matter of absolute necessity that the gas shall issue in thin streams, and that these streams shall be at once attacked by the hot air. In using Mr. Wenham's lamp, the gas is turned on until little spurs begin to show at the outer edge of the rim of flame, and then it is known that the gas is giving its maximum illuminating power. The light from the flame is thrown downward, and there are no pipes or fittings below to cast a shadow. The impure products of combustion can, with this lamp, be collected and carried out of the room, wherever a pipe for the purpose can be laid above the ceiling.

The light has been photometrically tested by Mr. F. W. Hartley, who is well known in gas engineering circles for his skill and experience in such works. When the light was tested at 45 degrees from the vertical, it gave him the following results:

Lamps tested.	Gas burned per hour.	Total light obtained.	Light per cubic foot of gas.
	Cubic feet.	Candles.	Candles.
No. 1	6·4	55·00	8·60
" 2	12·9	122·50	9·50
" 3	15·2	171·00	11·40

Mr. Hartley states that the vertical lighting power on the average of the tests was more than fifty per cent. greater than the angular lighting. In the foregoing table, "total light" and "light per cubic foot" mean the standard sperm candles, and the figures give the number of these which it would have been needful to burn at one time to produce a light equivalent to the Wenham lamp. The average amount of light yielded per cubic foot of gas burned from an average burner does not exceed the equivalent of 2·6 standard sperm candles. Mr. Hartley further estimates that an amount of light equivalent to that evolved from 1,000 cubic feet of gas, when burned from the average burners in use, at a cost of three shillings, may be obtained by the use of Wenham's smallest lamp at a cost of tenpence halfpenny, while, with the larger sizes, he esti-



mates the cost at ninepence halfpenny, and eightpence, respectively.

Dr. John Hopkinson, F.R.S., and Mr. George Livesey have also photometrically tested the light with the following results, which agree closely with those of Mr. Hartley:

Lamp.	Feet per hour.	Total light.	Equivalent per cubic foot.
		Candles.	Candles.
No. 1	6·4	54·1	8·5
" 2	12·8	121·6	9·4
" 3	15·1	173·9	11·4

The average light directly under the lamps at the same distance from the flame was about 35 per cent. more than at 45 degrees. The above tests were made at 45 degrees from the vertical, and with lamps furnished with reflectors.

The manufacture of the lamp is in the hands of the Wenham Patent Gas Lamp Company, Limited, 12 Rathbone Place, Oxford Street, London, and the manager is Mr. J. H. Sheldrake. The work is in the hands of skilled engineers, aided by valuable labor-saving machinery.

There is little doubt that, with the new gelatino-chloride papers, photographic printing by artificial light will shortly become very general, and that a present objection is the cost of magnesium on the one hand, or the length of exposure to gas-light on the other. In Mr. Wenham's lamp we have an intensely bright light at small expense, and a light with no fittings below to cast a shadow, so that printing frames can be laid on a table below it, and need no special support, as they do when exposed to a horizontal light. In fact, a vertical light is just what is wanted. If gas be employed for printing, we know of nothing better or cheaper for getting the best results from its combustion, than Mr. Wenham's lamp. We also think that the printing process might be quickened by substituting, for gelatino-chloride paper, a very slow gelatino-bromide paper in which the emulsion has been treated with bichromate of potash, which increases the vigor and brilliancy of the prints, although it lengthens the exposure. So far as our own experience in transparency-printing goes, the slower the gelatino-bromide plates, the more do the results resemble those obtained with gelatino-chloride plates, and, probably, the same principle holds good when the emulsion is spread upon paper.—*British Journal of Photography.*

THE FORMATION OF POISONOUS ALKALOIDS IN CHOLERA.*

EVER since the discovery of poisonous alkaloids found in the decomposing bodies of the dead, the subject has been variously discussed.

It may be questioned whether or not the same or analogous alkaloids do not form in the body during life, and thus, acting as a subtle poison, finally terminate life itself.

Notwithstanding the numerous scientific investigations which have been made to demonstrate the formation of these alkaloids, their existence has not to my mind been fully established.

In November last, I made an investigation as to the existence of these alkaloids in the bodies of two cholera patients that had been kindly put at my disposal by M. Hayem, both of the patients having died at the age of 63 of cholera at the St. Anthony Hospital; the first patient five days after being attacked by the disease; the second, the day after his admission to the hospital; both showing previous to death unmistakable cholera symptoms. The first had no treatment other than mere revulsion of the skin; the second, no medical treatment whatever.

An investigation of their internal organs 24 hours after the death of the first, and 12 hours after that of the second, gave me the following results:

By Stas' method I obtained an alkaloid noted for its pronounced alkaline qualities and its prompt chemical action; my researches were confined to the intestines, kidneys, liver, and to the venous blood of the heart, and I found a remarkable quantity of this alkaloid in the intestines (the quantity at least was equal to 2 centigrammes of pure crystallized hydrochlorate salt). The kidneys contained characteristic traces, the liver and blood exhibited such a small quantity as practically to amount to nothing.

This alkaloid is liquid, and possesses an acrid taste and an odor of hawthorn. Its reaction upon litmus paper was decidedly alkaline, being a base very energetic, and which is not liberated by alkaline bicarbonates, but only by alkalies.

The iodide of mercury and potassium produces a white precipitate. A solution of iodide of potassium and iodine gives a brown precipitate, and the same effect in solutions extremely diluted, while the iodide of mercury and potassium does not give any precipitation except that which takes place in the use of ordinary alkaloids.

Bromine water, as well as picric acid, gives a yellow precipitate.

Chloride of gold yields a yellowish white.

Tannin and bichloride of mercury give a concentrated white precipitate.

Chloride of platinum or bichromate of potassium does not produce any precipitation.

Ferricyanide and bichloride of iron, added to the solution of the alkaloid or of its salts, does not give immediately the reactions of the ptomaines, and does not at once develop itself.

Pure sulphuric acid poured upon the alkaloid produces a violet color, light and volatile.

The hydrochlorate salt in this alkaloid is neutral upon litmus paper, and crystallizes in long and fine transparent needles, extremely deliquescent.

I have studied the physiological action of this alkaloid in a water solution. The little quantities that I have been enabled to procure did not permit me to make any large number of experiments; however, small doses of 1 to 2 milligrammes injected under the skin of a frog did not produce any remarkable characteristic results.

The number of heart pulsations in the frog were somewhat diminished at first, and fluctuated from 39 to 34, and then again returned to 40. It will be observed that the pulsations varied but little. Upon another frog with which I experimented, I tried to verify the former experiments, and 20 minutes after the injection all muscular movement rapidly ceased, accompanied by bad characteristics.

I injected a young Guinea pig with what remained of the alkaloid; the quantity was equal to about 6 milligrammes of the hydrochlorate salt, which was injected hypodermically in the thigh; the physiological effects were very remarkable.

The following table will show the heart pulsations per minute:

Before the injection	258
Five minutes after	140
" " "	258
" " "	150
" " "	60
" " "	264
" " "	90
" " "	252
" " "	120
" " "	291
" " "	222
" " "	270
" " "	222
" " "	228
" " "	222
" " "	222
Two days after	246

Three-quarters of an hour after the injection the fore legs trembled violently, and the hind legs were immediately afterward similarly affected. The trembling, however, rapidly disappeared. The animal at once refused all nourishment, and died four days after the injection. After its death I verified my experiment by observing the ecchymosis of the lower or diaphragmatic pleura; the heart was somewhat distended, and was full of liquid blood; the brain was somewhat congested.

It will be observed that the most remarkable results were those of the periodic variations, which were noticeable in the beginning of the experiment, and in the number of heart pulsations, which varied perceptibly in the proportion of 1 to 5, and in the violent nervous trembling produced three-quarters of an hour after the injection.

It will be noticed from these experiments that the alkaloid is found in the intestines, and its presence is indicated only in a very small quantity in the kidneys, and its almost complete absence from the blood and liver would seem to indicate a rapid elimination through the urine.

* M. A. Villiers in the *Bulletin de la Societe Chimique de Paris*, Feb. 5, 1885.

I intend making some further investigations as to whether the same alkaloids are not present in the body during life, when afflicted with certain diseases, particularly that of typhoid fever.

The study of these alkaloids would perhaps give valuable therapeutic indications, if it is true that these diseases terminate themselves by poisoning the system: if such is the fact, can we not arrest the poison and give the sick patient a counter poison of the alkaloid which has produced the illness? At present, I have no theory to advance, and speculation is useless.

Perhaps in cholera we might try the continued application of iodine water in a way so as to transform and hold the alkaloid in an insoluble solution, when, if it produced an action too caustic upon the mucous membranes of the intestines, and particularly upon the cells of the epithelium, perhaps we could regulate its action by the iodide of starch.

The investigation of these alkaloids would have great interest in a toxicological sense. The structure un-

AN AVALANCHE IN NORTHERN ITALY.

doubtedly shows that it is not sufficient to be enabled to find in the internal organs of the body poisonous matter, and conclude therefrom that it is poison, but it is absolutely indispensable to define and ascertain the nature of this latter substance.

THE AVALANCHES IN PIEDMONT.

THE Subalpine valleys of Northwest Italy were recently visited in many places by immense falls of accumulated snow from the steep mountain sides, destroying villages and causing much loss of life. Such calamities have often happened in Switzerland and the Tyrol, in Savoy, and in Piedmont; and the scene delineated in our engraving does not exaggerate the terrible aspect which they may occasionally present. Huge stones and detached fragments of rock are frequently brought down with the enormous mass of snow, besides quantities of loose earth, shattering as well as covering the houses beneath. On the Piedmontese side of the Alps, especially in the Val di Susa and the Val d'Aosta, west and north of Turin, between the mountain ranges successively marked by Monte Viso, Mont Cenis, the St. Bernard Pass, and Monte Rosa, in the narrow valleys traversed by the upper streams of the Clusone and Dora Riparia, the Stura and the Dora Baltea, which all flow toward the Po, sad havoc is reported from this cause; and likewise in the neighborhood of Cuneo, some forty miles south of Turin, at the foot of the Maritime Alps. The Val di Susa, that of the Dora Riparia, due west of Turin, is familiar to all travelers by the Mont Cenis Railway; and the Val d'Aosta, opening into the great plain at Ivrea, has been a favorite resort of tourists. The southwestern valleys are celebrated in history as the abode of the Protestant Vaudois, or Waldenses; and all these provinces are inhabited by a loyal, honest, industrious people, whose sufferings deserve our sympathy on the present occasion. It is officially stated that eighteen lives have been lost in the province of Cuneo and thirty in the province of Ivrea. At Exilles, in the province of Susa, an avalanche swept away sixty-three persons, but twenty of them were rescued alive from beneath the snow. At Frassino, thirty dead bodies were recovered, but many more persons were missing. One avalanche, which crushed a whole family, measured over 150,000 cubic meters. Another buried instantaneously twenty-two houses, with their inhabitants. Many entire villages have been destroyed. The troops everywhere are giving admirable service in assisting to disinter those who have been buried by the snow. The Mont Cenis railway traffic was stopped during several days by the avalanches between Bardonecchia and Chiamonte, and most of the dwellings in several townships near Chiamonte and Exilles have been destroyed. The Prefect of Turin has sent troops to the spot to render what aid they can to the stricken population. It is also announced that at Sparone, near Ivrea, fifteen people have perished under an avalanche. At Cuneo it had been snowing steadily there for three days, and the snow was over 6 ft. deep. At the southern opening of the Col di Tende Tunnel two men were killed by an avalanche. The Prime Minister of Italy, Signor Depretis, has announced in the Chamber at Rome the intention of the Government to assist the afflicted localities. The list of disasters occupies columns of the Italian newspapers.—*Illustrated London News.*

[NATURE.]

PROTOPLASM.[1]

THE fact of a direct continuity between the protoplasmic contents of adjacent cells is an important factor in plant histology. The history of this subject is briefly as follows:

The individuality of the plant-cells, defended by Schleiden,[2] was first criticised by Hofmeister,[3] and more positively and later by Sachs.[4] For Sachs and also for Strasburger[5] the plant is only one cohering protoplasmic entity. Nägeli[6] has also in a recent work supposed that the protoplasm of each cell is in direct communication with that of the others, by means of delicate protoplasmic filaments.

So far the theoretical side of the question. The first *direct* observation was made in the year 1854, by Theodor Hartig,[7] and not by Sachs as Walter Gardiner[8] states. We find in Hartig's paper the following description of the continuity of sieve-tubes: "Behandelt man in Wasser macerirte Siebröhren mit Schwefelsäure, so erfolgt häufig eine völlige oder theilweise Trennung der beiden Endflächen, in welchem Falle genau zwischen den correspondirenden Ptychodearmen sich Fäden *ausziehen*, die durch Tod dieselbe Färbung und Structur zeigen wie die Ptychodearme selbst. Fig. 18 stellt einen solchen Fall dar."[9]

After Hartig's discovery, confirmed later by Hanstein and Sachs, Mohl, Nägeli, De Bary, Dippel, Wilhelm, Tauczewski, Russow, etc., examined the sieve-tubes and their plasmic connection. For a long time the connection of the sieve-tubes remained the only known fact until Bornet[10] and E. Perceval Wright[11] in 1878, J. G. Agardh[12] in 1879, and Schmitz[13] in 1883 (the connective filaments were seen), and further, in 1884, Th. Hick[14] and Kolderup-Rosenvinge[15] published some accounts of the communication between adjacent cells in the Florideæ. It seemed to me very probable that in the Cyanophyceæ also communications between the adjacent filament-cells would be found. At least the drawings that Wille[16] gives put one in mind of similar phenomena.

After J. G. Agardh,[17] Tangl,[18] in 1880, succeeded in proving the direct communication in phaneroganous plants between the endosperm cells. In the various papers of Russow,[19] Gardiner,[20] and Hillhouse,[21] these communications are stated in many cases to occur in the bast-parenchyma, the phloem-ray cells of numerous plants, in various pulvini, in the cells of the leaf of dionæa, in the cells of the stamens of berberis, in a great number of endosperm cells, and in various cortical tissues.

Finally, Terletzki[22] gave a brief account of the plasmic communication of the parenchyma-cells in the stem of some ferns. I have published also myself[23] a brief account of this interesting object, and described briefly the observations made during the summer of the past year. After Terletzki's paper I was induced to publish my observations, with the full details.[24] The physiological significance of the communication was, in the first instance, not understood; it was believed to be chiefly for the conduction of stimulus in the sensitive organs. But, after numerous observations, there was little doubt that the occurrence of communications between neighboring protoplasts is not the exclusive privilege of the sensitive organs, and I further claimed the universality of the communication (at least in tissues) in my first paper.[25] This universal occurrence is since confirmed by recent researches.

I have in my second paper[26] given the results of my investigations made on various vegetative tissues. It is superfluous to say anything on the importance of the

[1] "On the Continuity of Protoplasm, and on the Protoplasm of the Intercellular Spaces and the 'Middle Lamellary' Protoplasm, with special reference to the Loranthaceæ and Coniferæ," by Dr. Jules Schaarschmidt, *Privat-docent* of Cryptogamic Botany and the Anatomy of Plants, Assistant at the Botanic Institute and Gardens, Royal Hungarian University at Kolosvár. Contributed by the author.

[2] Schleiden, "Grundzüge der wissenschaftlichen Botanik," 1. aufl., 1842-43.

[3] Hofmeister, "Die Lehre von der Pflanzenzelle," Leipzig, 1867.

[4] Sachs, "Vorlesungen über Pflanzenphysiologie," p. 102, Leipzig, 1882.

[5] Strasburger, "Ueber der Bau und das Wachsthum der Zellhäute," p. 246, Jena, 1882.

[6] Nägeli, "Mechanisch-physiologische Theorie der Abstammungslehre," p. 41, München und Leipzig, 1884.

[7] Hartig, "Ueber die Querscheidewände zwischen den einzelnen Gliedern der Siebröhren in *Cucurbita pepo*," *Botanische Zeitung*, xii., col. 43, 1854.

[8] W. Gardiner, "On the Continuity of the Protoplasm through the Walls of Vegetable Cells." Sachs, *Arbeiten des Bot. Instituts in Würzburg*, iii., 1., p. 52, 1884.

[9] Hartig, *l. c.*, col. 43.

[10] Bornet. *Vide* Thuret et Bornet, "Études phycologiques," Paris, 1878.

[11] Wright, "The Formation of the so-called Siphons, and the Development of the Tetraspores in Polysiphonia," *Quart. Journ. Mic. Science*, July, 1878; *Transactions* of the Royal Irish Academy, xxvii., 1879.

[12] Agardh, "Florideernes Morphologi," *Stockholm Vet. Akad. Handl.*, xv., p. 140, 1879.

[13] Schmitz, "Untersuchungen über die Befruchtung der Florideen," *Sitz. Ber. d. Kgl. Akad. d. Wissensch.*, p. 219, Berlin, 1883.

[14] Hick, "On Protoplasmic Continuity in the Florideæ," *Journal of Botany*, xxii., p. 33, 1884.

[15] Kolderup-Rosenvinge, "Bidrag-til Polysiphonia's Morfologi," *Særtryk af Botanisk Tidsskrift*, xiv., p. 9, 1884, f. 10-14, 26-28, 72, 75.

[16] Wille, "Ueber die Zellkerne und die Poren der Wände bei den Phycochromaceen," *Ber. d. Deutschen Botan. Gesellsch.*, i., vi., p. 345, 1883, and *Bidrag-til Sydamerikas Algflora*, i.-iii., *Bihang till k. Svenska Vet. Akad. Handlingar*, viii., No. 18, p. 6, 1884.

[17] Agardh, *l. c.*

[18] Tangl, "Ueber offene Communication zwischen den Zellen des Endosperms einiger Samen," *Pringsheim Jahrb. f. wiss. Botanik*, xii., ii., p. 179, 1880.

[19] Russow, "Ueber Tüpfelbildung und Inhalt der Bastparenchym und Baststrahlenzellen der Dikotylen und Gymnospermen," *Sitz. Ber. Dorpater Naturforschergesellsch.*, p. 359, 1882.

[20] Gardiner, "On Open Communication between the Cells in the Pulvinus of *Mimosa pudica*," *Quart. Journ. Microsc. Sci.*, New Ser., xxii., p. 365, 1882.

"Some Recent Researches on the Continuity of the Protoplasm through the Walls of Vegetable Cells," *Ibid.*, xxiii., p. 701, 1883.

"On the Continuity of Protoplasm through the Walls of Vegetable Cells," *Proceed. Roy. Soc.*, p. 163, 1883.

"On the Continuity of the Protoplasm through the Walls of Vegetable Cells." Sachs, *Arbeiten d. Bot. Instit. Würzburg*, iii., 1., p. 52, 1884.

[21] Hillhouse, "Einige Beobachtungen über den intercellularen Zusammenhang von Protoplasma," *Botanisches Centralbl. atl.*, xiv., p. 86, 1883.

[22] Terletzki, "Ueber den Zusammenhang des Protoplasmas benachbarter Zellen und über das Vorkommen von Protoplasma in Zwischenzellräumen," *Ber. Deutsch. Botan. Gesellsch.*, ii., iv., p. 169, 1884.

[23] Schaarschmidt, "A protoplastok összeköttetésének sa sejtközi plasma előfordulásának néhány esetéről," *Magyar Növenytani Lapok*, viii., No. 84, p. 17, February, 1884; see Referate in the *Botanisches Centralblatt*, xviii., No. 18, 1884.

[24] Schaarschmidt, "A protoplastok összeköttetéséről és a sejtközi plasmáról különös tekintettel a Loranthaceákra és Coniferákra," *Ibid.*, No. 87, p. 65, July.

[25] Schaarschmidt, *Botanisches Centralblatt*, xviii., No. 18, 1884.

[26] Schaarschmidt, *Magyar Növenytani Lapok*, viii., p. 77, July, 1884.

methods employed in such investigations. For fixing the freshly collected materials I used alcohol, osmic or picric acid; all the observations described below were made upon fresh material, treated, after fixing for a few minutes, with strong or dilute sulphuric acid, so as to swell the cell-walls.[1] The fresh material was first cut in alcohol (or osmic or picric acid); the sections were then for a short time placed in a drop of sulphuric acid, and washed rapidly in a watch-glass with distilled water. After washings in several watch-glasses, the sections may be stained. For staining I first used the saffranine, and later solely the eosine (from Dr. Th. Schuchardt, Görlitz, Silesia). The eosine has a great and admirably defined selective staining power. It is a very excellent negative reagent for the cell-wall, and when employed with some precautions colors only or almost only the protoplasm. It is, however, requisite that a dilute solution of the dye should be made (1 part of eosine to 50-60 parts of water), and that the stained sections should be washed carefully (for ten to fifteen minutes) in water.

That the phenomena detailed below are not artificially produced by reagents is proved in certain instances. The presence of the connecting protoplasmic filaments in the *intact* (not swollen) *normal cell-wall or pit-closing membrane* was witnessed in the medullary cells of the mistletoe, the sections of which were merely mounted in water and stained with eosine.

I now proceed to give an account of the results I obtained with the various tissues in which the continuity of protoplasm was shown to exist.

Epidermis.—Glaucium Fischeri gave the first results. In the leaf-epidermis the connecting processes of the protoplasms, many in number (one for each pit), are well defined; the same is the case in that of Viscum and Loranthus, but in the latter plants the fine connecting-threads were also visible. From the protoplasms of the epidermis-cells radiate numerous processes toward the pits, and in any two neighboring cells the processes from the one protoplast are exactly opposite those proceeding from the other. *All the epidermis-cells*, as in *Ficus elastica*, are in direct communication with one another and with the "guard-cells" of the stomata. The same is also the case *in epidermis composed of several layers*. The connection is very difficult to make out, though visible after a moderate swelling in the *collenchymatic-hypoderm* (Rhus, Cotinus, *Cucurbita pepo*, Solanum, Liriodendron, etc.).

The *bark-parenchyma* is one of the most favorable objects for investigation, and even when the cell-wall has been very conspicuously swollen or dissolved, the connection is unaltered (Loranthus, Viscum, *Abies alba*, *Picea excelsa*, *Gingko biloba*, etc.). When no *hypoderm* exists, the protoplasts of the epidermic-cells should be directly connected with those of the bark-cells. Such is the case in Viscum and Loranthus. The epidermal cell-walls of these plants may have undergone considerable swelling, and so the connective processes become very extended, but the fine connective threads are still conserved. In the *leaf-parenchyma* (Viscum, Loranthus) the connection is very distinct, also in the cotyledons of *Phaseolus multiflorus*. It is very difficult to prove the communication in leaves where the parenchyma has been doubly differentiated, viz., into chlorenchyma and into pneumo-enchyma. The *medullary-parenchyma* of Loranthus or Viscum furnish excellent objects for such investigations; the fine bent threads (five to eight in number) can be very *distinctly examined* after a feeble swelling of the cell-wall. In the Coniferæ I find only the connective processes distinct (Gingko, etc.). In the Loranthaceæ the communication is to be directly seen between the *medullary-ray-cells* and *xylem-cells*, between the *phloem-ray-cells* and *bast-parenchyma;* finally between the *medullary-ray-cells* and the *sclerenchyma-cells* [these last are found in the neighborhood of the xylem (primary) vessels in Viscum.]

The *bast-fibers* of Viscum, Loranthus, are in direct communication with one another, and in Viscum the fibers of the inner-phloem also communicate with the medullary-cells. The communication between *cambium*, *young bast-fibers*, and *bast-parenchyma* in the Coniferæ can be demonstrated only with high powers. The communication and connection of the *soft-bast* protoplasts is eminently remarkable. These protoplasts remain in connection even after total dissolution of their cell-walls (Cucurbita, Coniferæ, Loranthaceæ, etc.). I investigated also the sieve-tubes, and have found that these in their entire length are connected with *neighboring sieve-tubes*, or *bast-parenchyma-cells*, or *collateral cells* (*Nebenzellen*) (Viscum, Loranthus, *Ficus elastica*, etc.). The connective threads are often strongly developed in Cucurbita. They assume the figure of a compressed sphere.

Xylem.—I may remark that the details of the xylem communications are very difficult to observe. In general I have studied the communication of the xylem elements best in the Loranthaceæ, and especially in Viscum. The xylem of the mistletoe is composed of libriform cells, compensating cells (*Ersatzzellen*), and vessels. The cell-walls of the libriform cells are very much thickened, and bear pits only on the middle part of the cell. These cells are variously curved and bent, and offer favorable conditions for investigation—but then the communication of the *libriform cells with one another*, *libriform cells + compensating cells*, and of the latter together can be easily seen. In the Coniferæ the communication of the xylem elements is only clear in the younger states. In the *young tracheides* the distinct threads could be very clearly seen. In the *older tracheides* merely a striation (caused by the threads) could be detected through the pit-closing membrane). As regards the occurrence of a direct continuity, the *xylem vessels* gave generally a negative result. Although in many instances the occurrence of protoplasm in the great xylem vessels could be demonstrated, still direct communications seemed to me to be extremely rare. I could find this direct connection in one instance in Loranthus. The great (but only the pitted) vessels were here connected with the adjacent cells.

Finally, the protoplasts of the secretory cells are also in direct communication with the neighboring protoplasts, such as in the resin-channel cells. The cells of the resin-channels are, in the Coniferæ, directly connected with the adjacent leaf or bark parenchyma, or phyllogen-cells. In the bark of Gingko I was also able to confirm the communication of the crystal-bearing cells (crystal-glands) with the bark-parenchyma cells. I have no doubt that the same structure would be equally well demonstrated in the various secretive cells and vessels. In all the observed cases the communication of adjacent protoplasts is effected by delicate wavy protoplasmic threads. The connective thread either in a round-about way traverses the sieve-pore pit-closing membrane, or directly traverses the cell-wall when the membrane is unpitted or the pits feebly developed. From a physiological point of view the pits form one of the most important arrangements.

The protoplasts are also in direct connection with the intercellular protoplasm. The intercellular plasm which fills the intercellular spaces was first observed by J. G. Agardh[1] in the Florideæ, and by Russow[2] (1882) in various phanerogamous plants. I have (1883) also studied (first in the bark of *Liriodendron tulipifera*) its occurrence in many phanerogamous plants, and published my observations in 1884.[3] At this time also Berthold published a paper[4] in which he confirmed its occurrence in many plants, and later Terletzki[5] gave some details. The observations of these authors established the occurrence of protoplasm between the parenchyma-cells in a small number of plants, but as I have stated this is not a rare phenomenon, but one of general occurrence, and I have found that the intercellular spaces of the true prosenchymatic tissues may also contain protoplasm.

I have investigated the plasma of the intercellular spaces in various collenchymatic, parenchymatic, and prosenchymatic tissues. For the investigation it is very important to use the reagents (absolute alcohol, picric acid, or osmic acid) very shortly before cutting the sections. Between the larenchyma cells, in the intercellular spaces, protoplasm will always be found (bark and medullary parenchyma of the Loranthaceæ, Gingko, etc.). In longitudinal sections made of thick (2½ cm.) branches of Viscum, the connection between the medullary parenchyma-cells and the protoplasm filling the intercellular spaces is also clearly to be seen. On the contrary, between the thin-walled cells which contain little protoplasm the intercellular plasm cannot, or in very rare instances, be detected (medulla of Phaseolus, Cucurbita, Sambucus, etc.). In the prosenchymatous tissues, *e. g.*, in the bast-fiber of Viscum—after moderate swelling with sulphuric acid—the intercellular protoplasm, when stained with eosine, is clearly to be observed. The connection of this intercellular protoplasm with the protoplasts of the fibers is easily seen. We find intercellular protoplasm also in the xylem, *e. g.*, in *Rhus cotinus*.

Most important is a fact which I have discovered in the course of my investigations, namely, the occurrence of inter-lamellar protoplasm. This was present very constantly in the leaves of mistletoe. The sections prepared with dilute sulphuric acid and stained, very exactly showed the fine plasmatic threads, corresponding in their disposition exactly to the middle lamella. This middle-lamellary "protoplasm" surrounded the protoplasts as a frame the picture, and ended in the protoplasm of the intercellular spaces. The threads are thicker at these points. The greatest precautions must be taken in the investigation of this middle-lamellary plasma; all very strong acids, etc., should be kept away from the prepared sections. When the cell-wall is very vigorously swelled, the fine processes which bind the protoplasts together appear penetrating into the plasma-frame. This plasma-frame surrounds each cell, and in a section the framework of lamellæ occur in all planes and in all successive sections, and all the various constituent threads appear to intersect one another at all angles; it is consequently clear that the middle-lamellary plasm forms a *plasmatic mantle* round the protoplasts which is increased at each edge with the pillar-form (of three to four sides) intercellular plasm portions.

The intercellular plasm preserves its vitality, and in some instances we observe that some changes take place in the intercellular spaces. The intercellular plasm may be observed to cover itself with a special cell-wall; this membrane is the product of the intercellular plasm. This protoplasm can transform itself into a true new cell. In many cases in various tissues we have found this new mode of cell-formation, thus in the collenchymatous tissues (hypoderm of Liriodendron, Ficus, Sambucus, Solanum, Cucurbita, etc.), or in the xylem (*Rhus cotinus*), in the common parenchymatous bark (Viscum, Loranthus, etc.), in the medulla, etc. These newly formed cells grow very fast, and are only in their form and appearance different from the older cells. This cell-formation is very rapid, and it appears at first sight that the number of the tissue elements is by these "intercellular cells" (*Interstitialceller* of J. G. Agardh,[6] who has observed this metamorphosis in the Florideæ), or "between-cells" (*Közti sejtek* in Hungarian), considerably increased. A consequence of this great and fast growth is the formation of new "secondary" or "tertiary" intercellular spaces round the newly formed or transformed cells.

General Results.—I will now briefly conclude with a statement of the general results of my investigations upon the communication of the protoplasts, and upon the intercellular and middle-lamellary plasm.

(1.) The protoplasts of all the tissues in united cells are in direct connection by means of finely attenuated protoplasmic threads.

(2.) The connective threads traverse the pit-closing membrane (which is of a sieve-plate structure), while in unpitted cells they traverse directly the cell-wall. By these threads is the communication between the connective processes which occupy the pit-cavity from both sides directly established.[7]

(3.) The intercellular plasm occurs not only in the intercellular spaces of the parenchymatic tissues, but also in those of true parenchymatic tissues.

(4.) This intercellular plasm contains, in many cases, chlorophyl-granules[8] (Viscum).

(5.) The intercellular plasm is in direct connection with the adjacent protoplasts.

(6.) Corresponding to the middle lamella around the cells, we find a plasmatic frame; the sides of this frame end in the "intercellular" plasma. This plasmatic frame forms a veritable mantle round the protoplasts, and is increased at each edge by an intercellular plasm portion, which latter has a pillar form.

(7.) The connective threads of the protoplasts traverse this "middle-lamellary" plasma; both are also connected.

(8.) The probable origin of the intercellular plasma is this: During the cell-division, when the division was almost ended, little cytoplasmic portions become included in the young cell-wall, and it is also very probable that the connective threads, in many instances, are the remainder of the "nuclear connective threads," and that the middle-lamellary protoplasm is the remainder of the "cell-plate." All these plasma portions are by the thickened cell-wall much compressed together, and therefore only visible or distinctly visible by the swelling of the cell-wall.

(9.) The intercellular plasm can cover itself with a cell-membrane, and in this way we find at the place of the intercellular spaces veritable new cells. About these new cells appear later new secondary or tertiary intercellular spaces.

(10.) The protoplasm of the crystal-bearing cells (crystal glands) and that of the resin-cannel cells is also in communication with the adjacent cells.

The protoplasts of the plants (composed from tissues) form a higher unity, one synplast.

[1] See, for details of my method, *Zeitschrift fur wissensch. Mikroskopie*, etc., I., ii., p. 201, 1884.

[1] *L. c.*, p. 140, etc.

[2] *L. c.*, p. 390, etc.

[3] In the *Magyar Novenytani Lapok*, viii., 1884, pp. 19, 74.

[4] Berthold, "Uber das Vorkommen von Protoplasma in Intercellularraumen, *Berichte der deutschen botan. Gesellsch.*, ii., 1884, 1., p. 20.

[5] *L. c.*, p. 169.

[6] *Botaniska Notiser*, 1884, p. 130.

[7] Gardiner has also observed this fact in the plants investigated by him; for this reason we give this in the first place.

[8] J. G. Agardh has also observed endochrome granules in the intercellular spaces of the Florideæ. See *Botaniska Notiser*, 1884, p. 108.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—The Great Cantilever Bridge over Niagara River.—With engraving 7697
Proposed New Bridge over the Thames.—2 figures 7698
Sound Castings and Factors of Safety 7698
The Last Trial of Armor Plates at Spezia.—10 figures 7699
Creeping of Rails 7699
Planetary Wheel Trains.—Elliptical epicyclic trains.—Varying velocity ratio.—Planetary trains with intermittent motion.—By Prof. C. W. MACCORD.—Three full pages of illustrations 7700
Emery Wheels and Emery Wheel Machinery.—By W. O. ROPES. 7698
Improved Silk Warping Machines.—2 figures 7700
Lubricating Oils.—By DR. ARVIN 7700

II. TECHNOLOGY.—The Intensification of Gelatine Plates.—By A. SPILLER 7697
Slag Cement 7698
Cements for Special Purposes 7699
Pavement of Kansas City, Mo 7699
The Wenham Light.—A lamp for obtaining brilliant and economical light from common gas.—1 figure 7700

III. ARCHITECTURE, ART, ETC.—Hall of the New Palace of Justice, Vienna.—With full page engraving 7696
Art in Sheet Metal.—With two engravings of statues made for the New Orleans Exhibition 7697

IV. MEDICINE, ETC.—The Formation of Poisonous Alkaloids in Cholera.—By M. A. VILLIERS 7700

V. MISCELLANEOUS.—Avalanches in Piedmont.—With engraving .. 7701
Protoplasm.—The Protoplasmic contents of adjacent cells an important factor of plant histology 7701

VI. BIOGRAPHY.—Benjamin B. Hotchkiss, inventor of the Hotchkiss gun, etc. 7695
Prof. Benjamin Silliman.—His labors in the departments of chemistry, mineralogy, etc., in Louisville and at Yale College 7695

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 40 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & Co., 361 Broadway, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.

Detroit Public Library